FICHTNER

Consulting Engineers Limited

Teesside Renewable Energy Plant

Port Clarence Energy Limited

Application for EP Variation – Dispersion Modelling Assessment

ENGINEERING CONSULTING

Document approval

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Management Summary

Fichtner Consulting Engineers Ltd (Fichtner) has been engaged by Port Clarence Energy Limited (the Client) to undertake a Dispersion Modelling Assessment to support the application for a variation to the Environmental Permit (EP) for the Teesside Renewable Energy Plant (the Facility), to enable the conversion of the Facility to the combustion of refuse derived fuel (RDF).

As the majority of the fuel handling, combustion and flue gas treatment systems have already been constructed, the majority of changes required to enable the Facility to combust RDF as a fuel are relatively minor with minimal requirements for the installation of 'new' equipment. The key modifications to the EP to facilitate the proposed changes to the combustion of RDF as a fuel are as follows:

- Additional EWC codes to allow for the processing of RDF as the primary fuel;
- Modifications to the fuel handling and storage arrangements to facilitate processing of RDF as the primary fuel;
- De-rating of the boiler and reduced maximum capacity due to the processing of RDF as the primary fuel;
- Modifications to the boiler and combustion control setting and the flue gas cleaning systems to facilitate the processing of RDF as the primary fuel; and
- Modifications to the ash handling systems.

This assessment has considered the following scenarios:

- the "Permitted Facility" – the model has been set up with data from the original EP application. This has been used to evaluate the impact of the permitted facility;
- The "Proposed Facility" – using the dispersion model inputs based on information provided by the technology supplier which account for changes to the flue gas parameters due to the change in fuel type and other operational changes being proposed as part of the EP variation; and
- the change between the two scenarios.

Dispersion Modelling of Emissions

The ADMS dispersion model is routinely used for air quality assessments to the satisfaction of the Environment Agency (EA). The model uses weather data from the local area to predict the spread and movement of the exhaust gases from the stack for each hour over a five-year period. The model takes account of wind speed, wind direction, temperature, humidity and the amount of cloud cover, as all of these factors influence the dispersion of emissions. The model also takes account of the effects of buildings and terrain on the movement of air. To set up the model, it has been assumed that the Facility operates for the whole year and continuously releases emissions at the emission limits set in the existing EP or to be included in the varied EP, as appropriate. The model has been used to predict the ground level concentration of pollutants on a long-term and short-term basis across a grid of points. In addition, concentrations have been predicted at the identified sensitive receptors.

Dispersion modelling of odour from the odour extraction system has also been undertaken to assess the impact of odour emissions outside of the installation boundary.

Approach and Assessment of Impact on Air Quality – Protection of Human Health

The air quality impact on human health has been assessed using a standard approach based on guidance provided by the EA. Using this approach, in relation to the AQALs set for the protection of human health the following can be concluded from the assessment.

1. Emissions from the operation of the Proposed Facility will not cause a breach of any AQAL.
2. The PC from the Proposed Facility is lower than the Permitted Facility for all pollutants and averaging periods due to reduced pollutant release rates, except for cadmium, mercury, group 3 metals, dioxins, and pollutants with short-term ELVs.
3. The change in impact at the point of maximum impact is ‘insignificant’ for all pollutants and averaging periods.
4. The PC for the Proposed Facility can be screened out as ‘insignificant’ for all pollutants and averaging periods except for annual mean VOCs as 1,3-butadiene. For those pollutants which cannot be screened out as ‘insignificant’, further analysis has been undertaken which shows that there is no risk of exceedance of an AQAL, and no significant impacts are predicted.

Approach and Assessment of Impact on Air Quality – Protection of Ecosystems

The impact of air quality on ecology has been assessed using a standard approach based on guidance provided by the EA. Using this approach, in relation to the Critical Level and Critical Loads set for the protection of ecology the following can be concluded from the assessment.

1. The impact of the Proposed Facility, and the change in impact, can be screened out as ‘insignificant’ at the identified ecological receptor (the Teesmouth and Cleveland Coast designated site), with the exception of the impact of the Proposed Facility on annual mean oxides of nitrogen.
2. When the baseline concentration of oxides of nitrogen is taken into account, the PEC is less than 70% of the Critical Level so the impact is ‘not significant’.

Approach and Assessment of Odour

The impact of air quality on ecology has been assessed using a standard approach based on guidance provided by the EA and institute of Air Quality Management (IAQM). Using this approach, in relation to the appropriate odour exposure benchmarks, the maximum odour concentration is predicted to be less than the benchmark of 1.5 OU_E/m^3 for ‘highly offensive’ odours. The odour concentrations at high sensitivity receptors is predicted to be much lower. Therefore, there should be no reasonable cause for annoyance due to odour releases from the odour control stack.

Summary and Conclusions

In summary, the assessment has shown that the change in impact as a result of varying the EP to change the Facility from a waste co-incineration plant to an incineration plant would not have a significant impact on local air quality, the general population or the local community. As such there should be no air quality constraint in granting the variation to the EP.

Contents

1 Introduction

1.1 Background

1.1.1 Purpose of the report

Fichtner Consulting Engineers Ltd (Fichtner) has been engaged by Port Clarence Energy Limited (the Client) to undertake a Dispersion Modelling Assessment to support the application for a variation to the Environmental Permit (EP) for the Teesside Renewable Energy Plant (the Facility), to enable the conversion of the Facility from the combustion of biomass to the combustion of refuse derived fuel (RDF). The Facility is located approximately 1 km east of the village of Port Clarence , in the administrative area of Stockton-on-Tees Borough Council (STBC). The location of the Facility is shown on Figure 1 of Appendix A.

1.1.2 Proposed operational changes

As the majority of the fuel handling, combustion and flue gas treatment systems have already been constructed, the majority of changes required to enable the Facility to combust RDF as a fuel are relatively minor with minimal requirements for the installation of 'new' equipment. The key modifications to the EP to facilitate the proposed changes to the combustion of RDF as a fuel are as follows:

- Additional EWC codes to allow for the processing of RDF as the primary fuel;
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- Modifications to the boiler and combustion control setting and the flue gas cleaning systems to facilitate the processing of RDF as the primary fuel; and
- Modifications to the ash handling systems.

1.1.3 Modelled scenarios

This assessment has considered the following scenarios:

- the "Permitted Facility" – the model has been set up with data from the original EP application. This has been used to evaluate the impact of the permitted facility;
- The "Proposed Facility" – using the dispersion model inputs based on information provided by the technology supplier which account for changes to the flue gas parameters due to the change in fuel type and other operational changes being proposed as part of the EP variation; and
- the change between the two scenarios.

The Facility has an Environmental Permit (EP) to operate (reference: EPR/MP3333WX). The Facility is currently regulated as a waste co-incineration plant and includes limits on emissions to air aligned with the those set out in the Industrial Emissions Directive (IED). The EP variation will align the emission limits with those set out in the IED for a waste incineration plant.

When considering the impact on human health, the predicted atmospheric concentrations have been compared to the Air Quality Assessment Levels (AQALs) for the protection of human health.

When considering the impact on ecosystems the predicted atmospheric concentrations have been compared to the Critical Levels for the protection of ecosystems. The deposition of emissions over a prolonged period can have nutrification and acidification impacts. An assessment of the long-term deposition of pollutants has been undertaken and the results compared to the habitat specific Critical Loads.

1.2 Structure of the report

This report has the following structure.

- National and international air quality legislation and guidance are considered in section 2.
- The background levels of ambient air quality are described in section 3.
- The residential properties and ecological receptors which are sensitive to changes in air quality associated with the Facility and identified in section 4.
- The inputs used for the dispersion model are contained in section 5.
- Details of the sensitivity analysis carried out is presented in section 6.
- The assessment methodology and results of the assessment of the impact of emissions on human health is presented in section 7.
- The assessment methodology and results of the assessment of the impact of emissions at ecological sites is presented in section 9.
- The conclusions of the assessment are set out in section 10.
- The Appendices include illustrative figures and detailed results tables.

2 Legislation Framework and Policy

2.1 Air quality assessment levels

European air quality legislation is consolidated under the Ambient Air Quality Directive (Directive 2008/50/EC), which came into force on 11 June 2008. This Directive consolidates previous legislation which was designed to deal with specific pollutants in a consistent manner and provides Ambient Air Directive (AAD) Limit Values for sulphur dioxide, nitrogen dioxide, benzene, carbon monoxide, lead and particulate matter with a diameter of less than 10 µm (PM_{10}) and a new AAD Target Value and Limit Value for fine particulates (those with a diameter of less than 2.5 µm ($PM_{2.5}$). The fourth daughter Directive - 2004/107/EC - was not included within the consolidation. It sets health-based Target Values for polycyclic aromatic hydrocarbons (PAHs), cadmium, arsenic, nickel and mercury, for which there is a requirement to reduce exposure to as low as reasonably achievable. Directives 2008/50/EC and 2004/107/EC are transposed under UK Law into the Air Quality Standards Regulations (2010). The regulations also extend powers, under Section 85(5) of the Environment Act (1995), for the Secretary of State to give directions to local authorities for the implementation of these Directives.

The UK Government and the devolved administrations are required under the Environment Act (1995) to produce a national air quality strategy. This was last reviewed and published in 2007. The Air Quality Strategy (AQS) sets out the UK's air quality objectives and recognises that action at national, regional and local level may be needed, depending on the scale and nature of the air quality problem. This is the method of the implementation of the AADT Limits and Targets. This includes additional targets and limits for 15-minute sulphur dioxide and 1,3-butadiene and more stringent requirements for benzene and PAHs, known as AQS Objectives.

The Air Quality Strategy defines "standards" and "objectives" in paragraph 17:

"For the purposes of the strategy:

- *standards are the concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive subgroups or on ecosystems; and*
- *objectives are policy targets often expressed as a maximum ambient concentration not to be exceeded, either without exception or with a permitted number of exceedances, within a specified timescale."*

The status of the objectives is clarified in paragraph 22, which also emphasises the importance of European Directives:

"The air quality objectives in the Air Quality Strategy are a statement of policy intentions or policy targets. As such, there is no legal requirement to meet these objectives except in as far as these mirror any equivalent legally binding limit values in EU legislation. Where UK standards or objectives are the sole consideration, there is no legal obligation upon regulators, to set Emission Limit Values (ELVs) any more stringent than the emission levels associated with the use of Best Available Techniques (BAT) in issuing permits under the PPC Regulations. This aspect is dealt with fully in the PPC Practical Guides."

In 2019 the UK Government published the Clean Air Strategy (CAS). This sets out methods by which air pollution from all sectors will be reduced. The CAS has not introduced any new air quality limits. However, the CAS sets out the actions required across all parts of the government to meet legally binding targets to reduce five key pollutants (fine particulate matter, ammonia, nitrogen oxides, sulphur dioxide, non-methane volatile organic compounds) by 2020 and 2030 and secure health public health benefits. The CAS also makes a commitment to bring forward primary legislation on clean air as outlined in the Environmental Act.

For other pollutants the Environment Agency (EA) set Environmental Assessment Levels (EALs) in the environmental management guidance document 'Air Emissions Risk Assessment for your Environmental Permit' (Air Emissions Guidance). The long-term and short-term EALs from this document have been used when the AQS does not contain relevant objectives. Standards and objectives for the protection of sensitive ecosystems and habitats are also contained within the Air Emissions Guidance and the Air Pollution Information System (APIS).

AAD Target and Limit Values, AQS Objectives, and EALs are set at levels well below those at which significant adverse health effects have been observed in the general population and in particularly sensitive groups. For the remainder of this report these are collectively referred to as Air Quality Assessment Levels (AQALs). Table 1, Table 2, and Table 3 summarise the air quality objectives and guidelines used in this assessment.

Table 1: Air Quality Assessment Levels (AQALs)

Pollutant	Limit value (µg/m³)	Averaging period	Frequency of exceedances	Source
Nitrogen dioxide	200	1 hour	18 times per year (99.79th percentile)	AQS Objective
	40	Annual	-	AQS Objective
Sulphur dioxide	266	15 minutes	35 times per year (99.9th percentile)	AQS Objective
	350	1 hour	24 times per year (99.73rd percentile)	AQS Objective
	125	24 hours	3 times per year (99.18th percentile)	AQS Objective
Particulate matter (PM_{10})	50	24 hours	35 times per year (90.41st percentile)	AQS Objective
	40	Annual	-	AQS Objective
Particulate matter ($PM_{2.5}$)	20	Annual	-	AQS Objective
Carbon monoxide	10,000	8 hours, running	-	AQS Objective
	30,000	1 hour		Air Emissions Guidance
Hydrogen chloride	750	1 hour	-	Air Emissions Guidance
Hydrogen fluoride	160	1 hour	-	Air Emissions Guidance
	16	Annual	-	Air Emissions Guidance
Ammonia	2,500	1 hour	-	Air Emissions Guidance
	180	Annual	-	Air Emissions Guidance
Lead	0.25	Annual	-	AQS Objective
Benzene	5.00	Annual	-	AQS Objective
	30	24 hour	-	Air Emissions Guidance

Pollutant	Limit value (µg/m³)	Averaging period	Frequency of exceedances	Source
1,3-butadiene	2.25	Annual, running	-	AQS Objective
PCBs	6	1-hour	-	Air Emissions Guidance
	0.2	Annual	-	Air Emissions Guidance
PAHs	0.00025	Annual	-	AQS Objective

As shown in Table 1, lead is the only metal included in the AQS. The AQS includes objectives to limit the annual mean to 0.5 µg/m³ by the end of 2004 and to 0.25 µg/m³ by the end of 2008. Only the first objective is included in the Air Quality Directive.

The fourth Daughter Directive on air quality (Commission Decision 2004/107/EC) includes target values for arsenic, cadmium and nickel. However, these values are the same as, or lower than, those included in the Air Emissions Guidance. Therefore, the Environmental Assessment Levels (EALs) from the Air Emissions Guidance shown in Table 2 have been used in this assessment.

Table 2: Environmental Assessment Levels (EALs) for Metals

Metal	Daughter Directive target level (µg/m³)	EALs (µg/m³)	
		Long-term	Short-term
Arsenic	0.006	0.006	-
Antimony	-	5	150
Cadmium	0.005	0.005	-
Chromium (II & III)	-	5	150
Chromium (VI)	-	0.0002	-
Cobalt	-	-	-
Copper	-	10	200
Lead	-	0.25	-
Manganese	-	0.15	1500
Mercury	-	0.25	7.5
Nickel	0.020	0.020	-
Thallium	-	-	-
Vanadium	-	-	1 (daily average)

Table 3: Critical Levels for the Protection of Vegetation and Ecosystems

Pollutant	Concentration (µg/m³)	Measured as	Source
Nitrogen oxides (as nitrogen dioxide)	75 / 200*	Daily mean	Air Emissions Guidance
	30	Annual mean	AQS Objective
Sulphur dioxide	10	Annual mean	Air Emissions Guidance

Pollutant	Concentration (µg/m³)	Measured as	Source
		for sensitive lichen communities and bryophytes and ecosystems where lichens and bryophytes are an important part of the ecosystem's integrity	
	20	Annual mean for all higher plants	AQS Objective
Hydrogen fluoride	5	Daily mean	Air Emissions Guidance
	0.5	Weekly mean	Air Emissions Guidance
Ammonia	1	Annual mean for sensitive lichen communities and bryophytes and ecosystems where lichens and bryophytes are an important part of the ecosystem's integrity	Air Emissions Guidance
	3	Annual mean For all higher plants	Air Emissions Guidance
Note: **only for detailed assessments where the ozone is below the AOT40 critical level and sulphur dioxide is below the lower critical level of 10 µg/m³* The *AOT40 for ozone is 6,000 µg/m³ calculated from accumulated hourly ozone concentrations – AOT40 means the sum of the difference between each hourly daytime (08:00 to 20:00 Central European Time (CET))) ozone concentration greater than 80 µg/m³ (40 ppb) and 80 µg/m³, for the period between 01 May and 31 July.*			

In addition to the Critical Levels set out in Table 3, the Air Pollution Information System (APIS) website[1] provides habitat specific Critical Loads for nitrogen and acid deposition. Full details of the habitat specific Critical Loads can be found in section 9.2.2.

2.2 Areas of relevant exposure

The AQALs apply only at areas of exposure relevant to the assessment level. The following table extracted from Local Authority Air Quality Technical Guidance (LAQM.TG(22)) explains where the AQALs apply.

Table 4: Guidance on Where AQALs Apply

Averaging period	AQALs should apply at:	AQALs should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building façades of residential	Building façades of offices or other places of work where members of

[1] www.apis.ac.uk

Averaging period	AQALs should apply at:	AQALs should generally not apply at:
	properties, schools, hospitals, care homes etc.	the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short-term.
24-hour mean and 8-hour mean	All locations where the annual mean AQAL would apply, together with hotels. Gardens of residential properties.	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short-term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean AQALs apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-minute mean	All locations where members of the public might reasonably be exposed for a period of 15-minutes or longer.	

Source: Box 1.1 LAQM.TG(22)

2.3 Industrial pollution regulation

Atmospheric emissions from industrial processes are controlled in England through the Environmental Permitting Regulations (2016) (and subsequent amendments). As identified in section 1.1, the Facility currently has an EP to operate. The EP includes conditions to ensure that the environmental impact of the operations is minimised. This includes conditions to prevent fugitive emissions of dust and odour beyond the boundary of the permitted activity, and limits on emissions to air.

The Industrial Emissions Directive (IED) (Directive 2010/75/EU), was adopted on 7 January 2013, and is the key European Directive which covers almost all regulation of industrial processes in the European Union (EU). Within the IED, the requirements of the relevant sector BREF (Best Available Techniques Reference documents) become binding as BAT (Best Available Techniques) guidance, as follows.

- Article 15, paragraph 2, of the IED requires that ELVs are based on best available techniques, referred to as BAT.
- Article 13 of the IED, requires that 'the Commission' develops BAT guidance documents (referred to as BREFs).
- Article 21, paragraph 3, of the IED, requires that when updated BAT conclusions are published, the Competent Authority (in England this is the EA) has up to four years to revise permits for facilities covered by that activity to comply with the requirements of the sector specific BREF.

The EA explain that ‘BAT’ means the available techniques which are the best for preventing or minimising emissions and impacts on the environment where ‘techniques’ include the technology used and the way the installation is designed, built, maintained, operated and decommissioned.

The Waste Incineration BREF was published by the European Integrated Pollution Prevention and Control (IPPC) Bureau in December 2019. Whilst the Facility will undergo the BREF review and the EP varied to align with the requirements of the BREF by the end of 2023, this assessment has been undertaken under the assumption that the Permitted Facility and the Proposed Facility will operate at the ELVs prescribed in the IED (with an additional monthly ELV for ammonia), to assess only the impact of the changes proposed as part of this EP variation application.

2.4 Local air quality management

In accordance with Section 82 of the Environment Act (1995) (Part IV), local authorities are required to periodically review and assess air quality within their area of jurisdiction, under the system of Local Air Quality Management (LAQM). This review and assessment of air quality involves assessing present and likely future ambient pollutant concentrations against AQALs. If it is predicted that levels at the façade of buildings where members of the public are regularly present are likely to be exceeded, then the local authority is required to declare an Air Quality Management Area (AQMA). For each AQMA, the local authority is required to produce an Air Quality Action Plan (AQAP), the objective being to reduce pollutant levels to below the relevant AQALs.

3 Baseline Air Quality

The Facility is located in Port Clarence, within the administrative area of STBC. The location of the Facility is shown on Figure 1 of Appendix A.

3.1 Air quality review and assessment

Under Section 82 of the Environment Act (1995) (Part IV), local authorities are required to undertake an ongoing review of air quality within their area of jurisdiction. STBC has not declared any AQMAs. The closest AQMA to the Facility is in Staithes, approximately 27 km to the east of the Facility. Taking this into consideration, the impact of emissions from the Facility on the Staithes AQMA and all other AQMAs is considered to be negligible. Therefore, the impact on AQMAs has been considered within this assessment.

3.2 National modelling – mapped background data

In order to assist local authorities with their responsibilities under LAQM, Defra provides modelled background concentrations of pollutants throughout the UK on a 1 km by 1 km grid. This model is based on known pollution sources and background measurements. In addition, mapped atmospheric concentrations of ammonia are available from the Centre for Ecology and Hydrology (CEH) throughout the UK on a 5 km by 5 km grid. Concentrations will vary over the modelling domain area. Therefore, the maximum mapped background concentration within the modelling domain (i.e. within 5 km) has been downloaded along with the concentrations for the grid squares containing the Facility. A summary is presented in Table 5. The mapped background concentrations are well below the relevant AQALs.

Table 5: Mapped Background Data

Pollutant	Annual Mean AQAL (µg/m³)	Concentration (µg/m³)		Dataset
		At Facility	Max Within 5 km of the Facility	
Nitrogen dioxide	40	18.10	28.68	Defra 2018 Dataset
Particulate matter (PM_{10})	40	10.88	14.98	Defra 2018 Dataset
Particulate matter ($PM_{2.5}$)	20	7.26	9.51	Defra 2018 Dataset
Carbon monoxide	-	N/A(1)	382	Defra 2001 Dataset
Sulphur dioxide	-	N/A(1)	34.30	Defra 2001 Dataset
Benzene	5	N/A(1)	0.53	Defra 2001 Dataset
1,3-butadiene	2.25	N/A(1)	0.32	Defra 2001 Dataset
Ammonia	180	2.9	3.4	CEH 2018 – 2020 Dataset

Note:
(1) No data available from the Defra 2001 dataset for the grid square containing the stack.

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Defra has not updated the mapped background datasets for carbon monoxide, sulphur dioxide, benzene and 1,3-butadeine since those produced for a base year of 2001. Defra provides factors for adjusting these pollutants to later years. The factors were published in 2003 and result in reduced concentrations in later years. As a conservative assumption the 2001 mapped background concentrations have been presented. However, due to a decline in local industry and shipping, it is anticipated that concentrations of pollutants in the area, in particular sulphur dioxide, have decreased substantially since 2001.

3.3 AURN and LAQM monitoring data

Monitoring locations are broadly classified into 'roadside' and 'background' locations. 'Background' locations, which may be urban, suburban, rural or industrial, are typically sited so that no single pollutant source is dominant and are intended to be representative of background concentrations over several square kilometres. 'Roadside' sites are dominated by road traffic emissions and only representative of concentrations in the immediate vicinity of the analyser. This analysis has considered background sites within 5 km, and roadside sites within 2 km, of the Facility.

The UK Automatic Urban and Rural Network (AURN) is a country-wide network of air quality monitoring stations operated on behalf of Defra. There is one urban industrial site (considered to be background rather than roadside type site) and one urban background site within 5 km of the Facility. These are the Billingham urban industrial site approximately 4.5 km north-west of the Facility and the Middlesbrough urban background site approximately 2.0 km south of the Facility. The most recent 5 years of monitoring results provided in Table 6. Monitoring undertaken in 2020 and 2021 will have been influenced by the effect of the Covid-19 pandemic so has been given less weight in determining appropriate baseline concentrations for the assessment.

Table 6: AURN Monitoring Data

Ref	Pollutant	Annual Mean Concentration (µg/m³)					
		Mapped Bg*	2017	2018	2019	2020	2021
Billingham	Nitrogen dioxide	14.9	18	17	17	13	13
Middlesborough	Nitrogen dioxide	18.4	13	14	16	12	13
Middlesborough	Sulphur dioxide	5.1	2	2	1	1	1
Middlesborough	PM_{10}	12.5	13	16	18	15	14
Middlesborough	$PM_{2.5}$	8.3	7	9	10	8	6
Middlesborough	Benzene	0.72	0.65	1.10	0.64	0.55	0.59
Note: **Mapped background data is for a base year of 2001 for sulphur dioxide and benzene and 2018 for all other pollutants.*							

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Excluding the years influenced by the effects of the Covid-19 pandemic:

- at the Billingham site, the mapped background nitrogen dioxide concentration is slightly lower than the measured concentration; whereas
- at the Middlesborough site, the mapped background nitrogen dioxide is slightly higher than the measured concentration. However, the mapped background PM concentration is slightly lower than the measured concentration.

Overall, the monitored concentrations of nitrogen dioxide, particulate matter and benzene are considered to be broadly similar to the mapped background dataset.

The measured concentrations of sulphur dioxide are significantly lower than the mapped background. However, this is expected as emissions of sulphur dioxide are known to have decreased substantially across the UK since the 2001 base year.

In addition to the national AURN, local authorities undertake monitoring of a range of pollutants as part of the LAQM review process. Local monitoring is undertaken by STBC. The neighbouring local authorities of Middlesbrough Borough Council (MBC) and Redcar and Cleveland Borough Council (RCBC) also operate some background monitoring locations within 5 km of the Facility, which have been included in this review.

Data from the most recent Annual Status Reports (ASRs) published by STBC, MBC and RCBC shows that background-type monitoring is undertaken at 9 locations within 5 km of the Facility and roadside monitoring is undertaken at 1 location within 2 km of the Facility.

Of the background-type monitoring locations within 5 km of the Facility referenced in the ASRs, two are the Billingham and Middlesbrough AURN sites referenced in Table 6. There are 7 other background-type sites within 5 km of the Facility, all of which monitor nitrogen dioxide. Three of these are diffusion tubes co-located in triplicate with the Middlesbrough AURN site. The monitoring results from these sites are presented in Table 7, with the most recent data available being from 2021. Again, little weight is given to monitoring undertaken in 2020 and 2021 due to the effect of the Covid-19 pandemic.

Table 7: Local Authority Monitoring Data

Ref	Distance from stack (km)	Annual Mean Concentration (µg/m³)					
		2018 Mapped Bg	2017	2018	2019	2020	2021
Background Monitoring							
R51	4.5	14.4	-	-	-	11.7	12.1
M2	1.6	21.3	18.5	20.8	18.0	12.6	15.4
M12	4.0	22.7	22.6	25.1	20.8	14.5	18.3
M15	2.1	18.4	20.9	24.3	20.4	14.1	16.9
M20-M22(1)	2.2	18.4	16.6	19.2	16.2	12.0	13.6
Roadside Monitoring							
M16	1.9	23.0	35.9	30.1	30.5	21.9	23.3
Note: *(1) M20 – M22 are co-located in triplicate with the Middlesbrough AURN site. The average concentration across the three diffusion tubes has been presented.*							

Source: STBC 2021 Air Quality Annual Status Report

As shown, no exceedance of any AQAL has been measured. The monitored concentrations at background sites are generally in line with the mapped background concentrations, except in 2020 – 2021 due to the Covid-19 pandemic. Concentrations at the roadside site from 2017 – 2019 were considerably higher than the mapped background due to the influence of road traffic emissions.

3.4 Summary of mapped background, AURN and LAQM data

In summary, where background monitoring is available it is generally similar to the 2018 Defra mapped background dataset. As a conservative measure, the maximum value from either the monitored background data or the mapped background concentrations for each pollutant has been used as the baseline background concentrations for the assessment. The exception is for sulphur dioxide, which has clearly decreased significantly since 2001 such that the mapped background concentration is no longer representative. The maximum monitored sulphur dioxide concentration at a background site of 2 μg/m³ has been used as the baseline background concentration.

3.5 Other national monitoring networks data

Neither the Defra mapped background dataset, AURN or LAQM include monitoring of other pollutants released from the Facility such as hydrogen chloride, hydrogen fluoride, VOCs (as 1,3-butadiene), metals or dioxins. As such, reference has been made to national modelling to determine a suitable baseline concentration.

3.5.1 Hydrogen chloride

Hydrogen chloride was measured until the end of 2015 on behalf of Defra as part of the UK Eutrophying and Acidifying Atmospheric Pollutants (UKEAP) project. This consolidates the previous Acid Deposition Monitoring Network (ADMN), and National Ammonia Monitoring Network (NAMN). Monitoring of hydrogen chloride ceased at the end of 2015 and none of the historic sites were located within 10 km of the site. Prior to the cessation of the monitoring concentrations were fairly constant.

The maximum annual average monitored within the UK between 2011 and 2015 was 0.71 μg/m³. In lieu of any recent representative monitoring this has been used as the baseline concentration for this assessment as a conservative estimate.

3.5.2 Hydrogen fluoride

Baseline concentrations of hydrogen fluoride are neither measured locally nor nationally, since these are not generally of concern in terms of local air quality. However, the EPAQS report 'Guidelines for halogens and hydrogen halides in ambient air for protecting human health against acute irritancy effects' contains some estimates of baseline levels, reporting that measured concentrations have been in the range of 0.036 μg/m³ to 2.35 μg/m³.

In lieu of any local monitoring, the maximum measured baseline hydrogen fluoride concentration has been used for the purpose of this assessment as a conservative estimate.

3.5.3 Ammonia

Ammonia is also measured as part of the UKEAP project. There are no UKEAP monitoring locations within 10 km of the Facility. In lieu of any representative monitoring data, the maximum mapped background concentrations within the modelling domain presented in Table 5 (3.4 μg/m³) has been used as the baseline concentration for the assessment for human health. For the assessment of ecological impacts, site-specific data has been obtained from APIS where required. This data is presented in section 9.3.

3.5.4 Volatile Organic Compounds

As part of the Automatic and Non-Automatic Hydrocarbon Network, benzene concentrations are measured at sites co-located with the AURN across the UK. In 2007, due to low monitored concentrations of 1,3-butadiene at non-automatic sites, Defra took the decision to cease non-automatic monitoring of 1,3-butadiene. There are no automatic 1,3-butadiene monitors within 10 km of the Facility.

In lieu of any local monitoring of 1,3-butadiene, the maximum mapped background concentrations within the modelling domain (0.32 µg/m³, as presented in Table 5) has been used as the baseline concentrations for the assessment. The maximum monitored benzene concentration (1.1 µg/m³, as presented in Table 6) exceeds the mapped background and has been used as the baseline concentration for the assessment.

3.5.5 Metals

Metals are measured as part of the Rural Metals and UK Urban/Industrial Networks (previously the Lead, Multi-Element and Industrial Metals Networks). Monitoring of metals was undertaken at the Redcar Normanby site until the end of 2013. This site is located approximately 9 km south-east of the Facility, with no other monitoring sites located within 100 km of the Facility. Therefore, it is considered that the historical monitoring data from Redcar Normanby is most representative of the conditions in the vicinity of the Facility. The most recent monitoring data from Redcar Normanby is presented in Table 8.

Table 8: Metals Monitoring – Redcar Normanby

Substance	Annual Mean AQAL (ng/m³)	Annual Mean Concentration (ng/m³) - 2013	as % of AQAL
Arsenic	6	0.39	6.50%
Cadmium	5	0.12	2.40%
Chromium	5,000	1.60	0.03%
Cobalt	-	0.03	-
Copper	10,000	2.20	0.02%
Lead	250	4.30	1.72%
Manganese	150	4.10	2.73%
Nickel	20	0.51	2.55%
Vanadium	-	0.65	

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As shown, the monitored concentrations are well below the respective AQALs.

There are also AQALs for antimony and mercury. However, these metals were not monitored at Redcar Normanby. Monitoring of antimony across the UK ceased at the end of 2013. Antimony was only monitored at background sites. The maximum monitored at any background site in 2013 was 1.30 ng/m³ at Detling, which has been used as the baseline concentration for the assessment. This value is only 0.026% of the annual mean AQAL of 5,000 ng/m³.

Mercury was widely monitored across the UK until the end of 2013 (and was monitored in the PM_{10} fraction at Redcar Normanby, although this excludes gaseous mercury). The maximum monitored at any urban or rural background site in 2013 was 2.10 ng/m³ at Cockley Beck, which has been used as the baseline concentration for the assessment. This value is only 0.84% of the annual mean AQAL of 250 ng/m³.

3.5.6 Dioxins, furans and polychlorinated biphenyl (PCBs)

Dioxins, furans and PBCs are monitored on a quarterly basis at a number of urban and rural stations in the UK as part of the Toxic Organic Micro Pollutants (TOMPs) network. There are no monitoring locations within 10 km of the Facility.

A summary of dioxin and furan and PCB concentrations from all monitoring sites across the UK is presented in Table 9 and Table 10. Note that monitoring data for dioxins and furans is only available up to the end of 2016 from the UK-Air website. For PCBs, data is only available up to the end of 2018 from the UK-Air website.

Table 9: TOMPS – Dioxin and Furans Monitoring

Site	Annual mean concentration (fgTEQ/m³)				
	2012	2013	2014	2015	2016
Auchencorth Moss	0.13	0.86	0.01	0.01	0.13
Hazelrigg	8.75	2.02	2.61	5.27	4.59
High Muffles	4.32	0.6	1.07	0.54	2.73
London Nobel House	15.42	3.47	2.89	4.34	21.27
Manchester Law Courts	32.99	10.19	16.52	5.94	12.23
Weybourne	9.3	2.34	1.61	1.42	16.32

Source: © Crown 2022 copyright Defra via uk-air.defra.gov.uk, licenced under the Open Government Licence (OGL).

Table 10:TOMPS – PCB Monitoring

Site	Annual mean concentration (pg/m³)				
	2014	2015	2016	2017	2018
Auchencorth Moss	23.23	24.27	25.32	19.09	12.31
Hazelrigg	25.84	41.68	52.58	33.15	22.22
High Muffles	26.11	33.43	37.76	31.63	8.86
London Nobel House	107.49	121.39	110.46	121.87	46.63
Manchester Law Courts	128.93	97.99	92.6	97.27	40.10
Weybourne	17.00	20.95	38.61	32.26	11.23

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As shown, the concentrations vary significantly between sites and years. As none of the TOMPs network sites are located in close proximity to the Facility, the maximum monitored concentrations (32.99 fg/TEQ/m³ for dioxins and furans and 128.93 pg/m³ for PCBs) have been used as the baseline concentrations for the assessment.

3.5.7 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are monitored as part of the PAH network. For the purpose of this assessment, benzo(a)pyrene is considered as this is the only PAH for which an AQAL has been set. The closest monitoring site is at Middlesbrough, co-located with the AURN site. A summary of benzo(a)pyrene concentrations from Middlesbrough and all background monitoring sites within the UK is presented in the following table.

Table 11: National Benzo(a)pyrene Monitoring

Site	Quantity	AQAL	Annual Mean Concentration (ng/m³)				
			2017	2018	2019	2020	2021
Middlesbrough	-	0.25	0.14	0.17	0.18	0.13	0.18
All UK Background Monitoring	Minimum	0.25	0.01	0.02	0.01	0.01	0.02
	Maximum	0.25	0.86	0.74	0.83	0.55	0.72
	Average	0.25	0.20	0.18	0.22	0.16	0.20

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The concentrations measured at Middlesbrough are at the lower end of the range monitored at background sites across the UK. The locally monitored concentration is considered most representative, so the maximum monitored at Middlesbrough in the last 5 years (0.18 ng/m³) has been used as the baseline concentration for this assessment.

3.6 Summary

Table 12 outlines the values for the annual average baseline concentrations that have been used to evaluate the impact of the Facility. The choice of baseline concentration will be considered further if the impact of the Facility cannot be screened out as 'insignificant'.

Table 12: Summary of Baseline Concentrations

Pollutant	Annual Mean	Units	Source
Nitrogen dioxide	28.68	µg/m³	Maximum mapped background concentration from across the modelling grid – Defra 2018 dataset
Sulphur dioxide	2.00	µg/m³	Maximum monitored at Middlesbrough 2017 - 2021
Particulate matter (as PM_{10})	18.00	µg/m³	Maximum monitored at Middlesbrough 2017 - 2021
Particulate matter (as $PM_{2.5}$)	10.00	µg/m³	Maximum monitored at Middlesbrough 2017 - 2021
Carbon monoxide	382	µg/m³	Maximum mapped background concentration from across the modelling grid – Defra 2018 dataset
Benzene	1.10	µg/m³	Maximum monitored at Middlesbrough 2017 - 2021
1,3-butadiene	0.32	µg/m³	Maximum mapped background concentration from across the modelling grid – Defra 2001 dataset
Ammonia	3.40	µg/m³	Maximum mapped background concentration from across the modelling grid – CEH 2018-2020 dataset
Hydrogen chloride	0.71	µg/m³	Maximum monitored concentration across the UK 2011 to 2015

Pollutant	Annual Mean	Units	Source
Hydrogen fluoride	2.35	µg/m³	Maximum measured concentration from EPAQS report
Mercury	2.10	ng/m³	Maximum monitored at a UK background site in 2013
Antimony	1.30	ng/m³	Maximum monitored at a UK background site in 2013
Arsenic	0.39	ng/m³	Maximum monitored at Redcar Normanby in 2013
Cadmium	0.12	ng/m³	
Chromium	1.60	ng/m³	
Chromium VI(1)	0.32	ng/m³	
Cobalt	0.03	ng/m³	
Copper	2.20	ng/m³	
Lead	4.30	ng/m³	
Manganese	4.10	ng/m³	
Nickel	0.51	ng/m³	
Vanadium	0.65	ng/m³	
PaHs	0.18	ng/m³	Maximum monitored at Middlesbrough, 2017 - 2021
Dioxins and Furans	32.99	fg ITEQ /m³	Maximum monitored across the UK 2012 to 2016
PCBs	128.93	pg/m³	Maximum monitored across the UK 2014 to 2018

Notes:

(1) Chromium VI is assumed to be 20% of total chromium.

4 Sensitive Receptors

4.1 Human sensitive receptors

The general approach to the assessment is to evaluate the highest predicted PC to ground level concentrations. In addition, the predicted ground level PC at discrete sensitive receptors has been evaluated. These represent the residential receptors most likely to experience a significant impact as a result of the operation of the Facility, along with any schools and care homes identified within approximately 2.5 km of the Facility. No hospitals have been identified within this distance. These sensitive receptors are displayed in Figure 2 of Appendix A and listed in Table 13. A as shown, there are few receptors as the Facility is mostly surrounded by open land and industrial/brownfield areas.

Table 13: Human Sensitive Receptors

ID	Name	Location			Distance from Facility Stack (km)
		X (m)	Y (m)	Z (m)	
R1	Saltview Terrace	450094	521645	0	0.94
R2	Queen's Terrace	449780	521820	0	1.24
R3	Middlesbrough college	450144	520877	0	1.25
R4	Lower East Street	449819	520885	0	1.49
R5	High Clarence Primary School	449478	521976	0	1.56
R6	Elizabeth House Care Home	450838	519776	0	2.00
R7	King George's Terrace	452620	520975	0	1.78

4.2 Ecological sensitive receptors

A nature conservation screening report was obtained from the EA which detailed the sensitive receptors requiring assessment, in accordance with the following screening distances laid out in the Air Emissions Guidance:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs), or Ramsar sites within 10 km of the Facility;
- Sites of Special Scientific Interest (SSSIs) within 2 km of the Facility; and
- National Nature Reserves (NNR), Local Nature Reserves (LNRs), local wildlife sites (LWSs) and ancient woodlands within 2 km of the Facility. There are collectively referred to as local nature sites.

The sensitive ecological receptors identified in the nature conservation screening report are displayed in Figure 3 and are listed in Table 14. A review of the citation and APIS website for each site has been undertaken to determine if lichens or bryophytes are an important part of the ecosystem's integrity. If lichens or bryophytes are present, the more stringent Critical Level has been applied as part of the assessment.

Table 14: Ecological Sensitive Receptors

ID	Site	Designation	Closest point to Facility		Distance from Facility at closest point (km)	Lichens/ bryo-phytes present
			X (m)	Y (m)		
European and UK Designated Sites						
E1	Teesmouth and Cleveland Coast	Ramsar/ SPA/SSSI	450948	521808	0.1	No
Local Nature Sites						
-	None identified	-	-	-	-	-

As the Teesmouth and Cleveland Coast designated site covers a large areas around the Facility, the maximum PC at ground level within this site has been extracted and assessed.

Reference should be made to section 9.2.2 for full details of the habitats present and the habitat-specific Critical Loads.

5 Modelling Methodology

5.1 Selection of model

Detailed dispersion modelling was undertaking using the model ADMS 5.2, developed and supplied by Cambridge Environmental Research Consultants (CERC) This is a new generation dispersion model, which characterises the atmospheric boundary layer in terms of the atmospheric stability and the boundary layer height. In addition, the model uses a skewed Gaussian distribution for dispersion under convective conditions, to take into account the skewed nature of turbulence. The model also includes modules to take account of the effect of buildings and complex terrain.

ADMS is routinely used for modelling of emissions for planning and Environmental Permitting purposes to the satisfaction of the EA and local authorities. An analysis of the variation in model outputs has been undertaken and the maximum predicted concentration for each pollutant and averaging period has been used to determine the significance of any potential impacts.

5.2 Source and emissions data

The source and emissions input data utilised within the modelling are presented in Table 15 to Table 17. The data for the Permitted Facility is taken from design data used in the AQA submitted with the most recent EP variation application. All data for the Proposed Facility has been provided by the technology provider for the Facility, based on the design data for the change from a co-incinerator to an incinerator.

The data for the Proposed Facility is based on the design thermal input of the boiler of 102 MWth, a design fuel net calorific value (NCV) of 11 MJ/kg, and a design throughput of 33.4 tonnes per hour (tph). The maximum mechanical throughput of the Proposed Facility is 38 tph. However, operating at this throughput at the design NCV would result in thermal overload. At the maximum throughput of 38 tph, the NCV to achieve 102 MWth input is 9.7 MJ/kg. This higher throughput at lower NCV would likely result in a slight increase in pollutant release rate but would also result in an increase in actual volumetric flow rate and associated increase in efflux velocity, which would improve dispersion. As such, the ground-level impact of emissions would be expected to be very similar for all combinations of NCV and throughput resulting in the design thermal input of 102 MWth. Therefore, it is considered appropriate to model the operation of the Facility at the design point.

Table 15: Source Data

Item	Unit	Permitted Facility	Proposed Facility
Stack data			
Height	m	111	
Internal diameter	m	2.30(1)	2.40(1)
Location	m, m	451021.8, 451021.8	
Flue gas conditions			
Temperature	°C	114.0	117.1
Exit moisture content	% v/v	17.22%	19.90%
Exit oxygen content	% v/v dry	4.90%	5.50%
Reference oxygen content	% v/v dry	6%	11%

Item	Unit	Permitted Facility	Proposed Facility
Volume at reference conditions (dry, ref O_2)	Nm^3/h	165,142	217,881
	Nm^3/s	45.87	60.52
Volume at actual conditions	Am^3/h	263,376	250,320
	Am^3/s	73.16	69.53
Flue gas exit velocity	m/s	17.61	15.37

Notes:

(1) Dispersion modelling for the most recent EP variation based on stack diameter of 2.3 m. The as-built diameter is 2.4 m The diameter of 2.3 m for the Permitted Facility has been retained to allow a comparison with the impact of the Facility as currently permitted.

Table 16: Stack Emissions Data – Daily or Periodic ELV

Pollutant	Permitted Facility(1)		Proposed Facility(2)	
	Conc. (mg/Nm^3)	Release Rate (g/s)	Conc. (mg/Nm^3)	Release Rate (g/s)
Oxides of nitrogen (as NO_2)	300	13.762	200	12.105
Sulphur dioxide	75	3.440	50	3.026
Carbon monoxide(3)	75	3.440	50	3.026
Fine particulate matter (PM)(4)	15	0.688	10	0.605
Hydrogen chloride	15	0.688	10	0.605
Volatile organic compounds (as TOC)	15	0.688	10	0.605
Hydrogen fluoride	1.5	0.069	1	0.061
Ammonia (daily)	15	0.688	10	0.605
Ammonia (monthly)	10.5	0.482	7	0.424
Cadmium and thallium	0.05	2.294 mg/s	0.05	3.026 mg/s
Mercury	0.05	2.294 mg/s	0.05	3.026 mg/s
Other metals(5)	0.5	0.023	0.5	0.030
Benzo(a)pyrene (PAHs)(6)	0.3 µg/Nm^3	0.014 mg/s	0.2 µg/Nm^3	0.012 mg/s
Dioxins and furans	0.1 ng/Nm^3	4.587 ng/s	0.1 ng/Nm^3	6.052 ng/s
PCBs(7)	7.5 µg/Nm^3	0.344 mg/s	5 µg/Nm^3	0.303 mg/s

Notes:

All emissions are expressed at reference conditions of dry gas, reference oxygen, 273.15K.

(1) Reference oxygen content for the Permitted Facility is 6%.

(2) Reference oxygen content for the Proposed Facility is 11%.

(3) Averaging period for carbon monoxide is 95% of all 10-minute averages in any 24-hour period.

(4) As a worst-case it has been assumed that the entire PM emissions consist of either PM10 or PM2.5 for comparison with the relevant AQALs.

Pollutant	Permitted Facility[(1)]		Proposed Facility[(2)]	
	Conc. (mg/Nm^3)	Release Rate (g/s)	Conc. (mg/Nm^3)	Release Rate (g/s)
(5) Other metals consist of antimony (Sb), arsenic (As), lead (Pb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V). *(6) 0.2 µg/m³ is the maximum recorded at a UK plant (2019 Waste Incineration BREF, Figure 8.121). This is assumed to be the emission concentration for the Facility.* *(7) Table 3.8 of the 2006 Waste Incineration BREF states that the annual average total PCBs is less than 0.005 mg/Nm³ (dry, 11% oxygen, 273K). In lieu of other available operational data, this has been assumed to be the emission concentration for the Facility.*				

As shown in Table 16 the release rate of pollutants from the Proposed Facility is lower than that from the Permitted Facility, except for cadmium and thallium, mercury, other metals, and dioxins. The ELVs for these pollutants are the same for both waste co-incineration plants and incineration plants but are expressed at different reference oxygen contents. This means that, in effect, an incinerator is permitted to release 50% more of these pollutants on a g/s basis than a co-incinerator.

The Permitted Facility is not subject to short-term emission limits. This EP variation will introduce short-term emission limits for the Proposed Facility. For emissions at the short-term ELVs, the impact of the Proposed Facility alone has been considered, without reference to the impact of the Permitted Facility.

Table 17: Stack Emissions Data – Short Term (Proposed Facility Only)

Pollutant	Conc. (mg/Nm^3)	Release Rate (g/s)
Oxides of nitrogen (as NO_2)	400	24.209
Sulphur dioxide	200	12.105
Carbon monoxide[(1)]	150	9.078
Fine particulate matter (PM)[(2)]	30	1.816
Hydrogen chloride	60	3.631
Volatile organic compounds (as TOC)	20	1.210
Hydrogen fluoride	4	0.242
Notes: *All emissions are expressed at reference conditions of dry gas, 11% oxygen, 273.15K.* *(1) Averaging period for carbon monoxide is 95% of all 10-minute averages in any 24-hour period.* *(2) As a worst-case it has been assumed that the entire PM emissions consist of PM_{10} for comparison with the relevant short term AQAL.*		

5.3 Other inputs

5.3.1 Modelling domain

Modelling has been undertaken over a grid of 10.0 x 10.0 km with grid spacing of 100 m. This is much less than 1.5 times the stack height as recommended in LAQM TG(22). Reference should be made to Figure 5 of Appendix A for a graphical representation of the modelling domain.

Table 18: Modelling Domain

Parameter	Value
Grid Spacing (m)	100
Grid Start X	446000
Grid Finish X	456000
Grid Start Y	516800
Grid Finish Y	526800

5.3.2 Meteorological data and surface characteristics

The impact of meteorological data used in the assessment has been taken from Teesside International Airport (formerly Durham Tees Valley Airport) for the years 2017 – 2021. Teesside International Airport is located approximately 16 km to the southwest of the Facility and is the closest and most representative meteorological station available, bring located on relatively flat terrain around 30 m above sea level. The next closest site is Loftus, located around 22 km to the east on a hill over 150 m in elevation in a coastal location. As such, it is not representative of the low-lying, non-coastal surroundings of the Facility. Data capture from Teesside International Airport is around 57%. The missing temperature, relative humidity, and precipitation data has been filled in from Durham, and wind direction, wind speed, and cloud cover from Leeming. Although not as close to the Facility as Teesside International Airport, (around 30 km north-west for Durham and 38 km south-west for Leeming) these sites are lower in elevation than Loftus (40 m for Leeming and 100 m for Durham) so are considered the most representative sites from which to obtain the missing data. With the infilled data, the final data capture is 100%. There is not an alternative meteorological site sufficiently representative of the surroundings of the Facility to investigate the effect of using alternative meteorological data.

The EA recommends that 5 years of data is used to take into account inter-annual fluctuations in weather conditions. Wind roses for each year are presented in Figure 7.

The minimum Monin-Obukhov length can be selected in ADMS for both the dispersion site and the meteorological site. This is a measure of the minimum stability of the atmosphere and can be adjusted to account for urban heat island effects which prevent the atmosphere in urban areas from ever becoming completely stable. The minimum Monin-Obukhov length has been set to 30 m for the dispersion site and 10 m for the meteorological site. The value of 30 m is recommended by CERC for mixed urban/industrial areas and is considered appropriate for the surroundings of the dispersion site, and is consistent with the value used in the previous EP variation application.

The value of 10 m is recommended by CERC for small towns <50,000 inhabitants and is considered appropriate for the surroundings of the meteorological site.

The surface roughness length can be selected in ADMS for both the dispersion site and the meteorological site. The surface roughness has been set to 0.2 m for the meteorological site, which is appropriate for the relatively open surroundings of Teesside International Airport.

The surface roughness length varies widely across the modelling domain, from very low values over the Tees estuary to much higher values over built-up areas. To account for the varying surface roughness length a spatially-varying surface roughness file have been generated. The land-use class for each point in the file has been extracted from the CORINE Land Cover database[2] and cross-referenced with the most likely surface roughness length value[3].

The parameters for the spatially-varying surface roughness file are shown in Table 19 and a visual representation shown in Figure 5.

Table 19: Spatially Varying Surface Roughness File Parameters

Parameter	Value
Grid spacing (m)	100
Grid points	112 x 112
Grid Start X (m)	445450
Grid Finish X (m)	456550
Grid Start Y (m)	516250
Grid Finish Y (m)	527350

Table 20: Surface Roughness Lengths Used for Different Land Use Classes

Land Use Classification	Corine 2018 Land Use Codes	Surface Roughness Length (m)
Continuous urban fabric	111	1.2
Forest	311	0.75
Green urban areas	141	0.6
Discontinuous urban fabric, industrial or commercial units, sport and leisure facilities, port areas	112, 121, 142, 123	0.5
Road and rail networks and associated land	122	0.075
Non-irrigated arable land, inland marshes, salt marshes	211, 411	0.05
Pastures, sclerophylous vegetation, moors and heathland	231, 321, 322	0.03
Sparsely vegetated areas, dump sites	333, 131	0.005
Intertidal flats	423	0.0005
Water(1)	511, 512, 523	0.0001
Notes: *(1) The 'most likely' value for water is given as zero. ADMS cannot model a surface roughness length of zero, so areas of water have been assigned a roughness length of 0.0001 m which is the value recommended by CERC for 'sea'.*		

A summary of the meteorological parameters used in the dispersion modelling is shown in Table 21.

2 https://land.copernicus.eu/pan-european/corine-land-cover

3 Taken from "Roughness length classification of Corine Land Cover classes", Megajoule Consultants, 2007.

Table 21: Meteorological parameters

Parameter	Dispersion Site Value (m)	Met Site Value (m)
Surface roughness length	Variable	0.2
Minimum Monin-Obukhov length	30	10

5.3.3 Terrain

CERC recommends that, where gradients within 500 m of the modelling domain are greater than 1 in 10, the complex terrain module within ADMS (FLOWSTAR) should be used. A review of the local area has deemed that the effect of terrain should be taken into account in the modelling, although gradients greater than 1 in 10 are located to the west of the modelling domain and are unlikely to have a large effect on concentrations at the point of maximum impact.

A terrain file large enough to cover the output grid of points was created using Ordnance Survey Terrain 50 data. The parameters of the terrain files used are outlined in Table 22, and presented graphically in Figure 6.

Table 22: Terrain File Parameters

Parameter	Value
Grid spacing (m)	100
Grid points	112 x 112
Grid Start X (m)	445450
Grid Finish X (m)	456550
Grid Start Y (m)	516250
Grid Finish Y (m)	527350

5.3.4 Buildings

The presence of adjacent buildings can significantly affect the dispersion of the atmospheric emissions in various ways:

- Wind blowing around a building distorts the flow and creates zones of turbulence. The increased turbulence can cause greater plume mixing.
- The rise and trajectory of the plume may be depressed slightly by the flow distortion. This downwash leads to higher ground level concentrations closer to the stack than those which would be present without the building.

The EA recommends that buildings should be included in the modelling if they are both:

- Within 5L of the stack (where L is the smaller of the building height and maximum projected width of the building); and
- Taller than 40% of the stack.

The ADMS 5.2 user guide also states that buildings less than one third of the stack height will not have any effect on the dispersion calculations in the model.

A review of the site layout has been undertaken and it has been determined that the only building tall enough to affect dispersion from the 111 m tall stack is the boiler hall. The details of the building included in the model are presented in Table 23. The height of the building has been modelled as the highest point of the structure. A site plan showing the building included in the model is presented in Figure 8.

Table 23: Building Details

Building	Centre Point		Height (m)	Width/ Diameter (m)	Length (m)	Angle (°)
	X (m)	Y (m)				
Boiler Hall	451015	521718	41.5	41.5	28.0	0

5.3.5 NOx chemistry

The Facility will release nitric oxide (NO) and nitrogen dioxide (NO_2) which are collectively referred to as oxides of nitrogen (NOx). In the atmosphere, NO will be converted to NO_2 in a reaction with ozone (O_3) which is influenced by solar radiation. Since the AQALs are expressed in terms of NO_2, it is important to be able to assess the conversion rate of NO to NO_2.

Ground level NOx concentrations have been predicted through dispersion modelling. NO_2 concentrations reported in the results section assume 70% conversion from NOx to NO_2 for annual means and a 35% conversion for short term (hourly) concentrations, based upon the worst-case scenario specified in the EA's guidance for dispersion modelling[4] which is appropriate where the primary NO_2 to NOx ratio is less than 10%. Given the short travel time to the areas of maximum concentrations, this approach is considered conservative.

5.4 Baseline concentrations

Baseline concentrations for the assessment have been derived from monitoring and national mapping as presented in section 3. For short term averaging periods, the baseline concentration has been assumed to be twice the long-term ambient concentration in accordance with the Air Emissions Guidance.

[4] https://www.gov.uk/guidance/environmental-permitting-air-dispersion-modelling-reports

6 Sensitivity Analysis

The sensitivity of the dispersion modelling results to various input parameters has been tested in accordance with EA guidance on dispersion modelling reports[5]. This has been undertaken using meteorological data for 2018, which is the year which results in the maximum annual mean impact.

6.1 Surface roughness

The sensitivity of the results to using varying surface roughness length has been considered by running the model with a variety of surface roughness lengths for the dispersion site. For all sensitivity analysis the impact of changing model parameters on the maximum annual mean and short-term concentrations of oxides of nitrogen have been considered.

The following parameters have been kept constant:

- Scenario – Proposed Facility;
- Grid – 10 x 10 km at 100 m resolution;
- Buildings – included;
- Terrain file – included at 64 x 64 resolution;
- Meteorological site surface roughness – 0.2 m;
- Dispersion site Monin-Obukhov length – 30 m;
- Meteorological site Monin-Obukhov length – 10 m; and
- Meteorological data used – Teesside International Airport 2018.

The contribution of the Facility to the ground level concentrations of oxides of nitrogen at the point of maximum predicted concentration and maximum impacted receptor are presented in Table 24.

Table 24: Surface Roughness Sensitivity Analysis

Surface roughness (m)	Oxides of nitrogen PC (µg/m³)			
	Point of maximum impact		Maximum impacted receptor	
	Annual mean	Max 1-hour mean	Annual mean	Max 1-hour mean
Varying	**0.48**	**34.75**	**0.27**	**30.15**
0.2	0.40	31.76	0.27	30.12
0.3	0.44	32.07	0.28	29.40
0.5	0.50	31.93	0.28	26.87
0.7	0.55	31.70	0.29	27.44
% Change from Varying				
0.2	-15.88%	-8.60%	-0.56%	-0.09%
0.3	-7.83%	-7.69%	1.38%	-2.50%
0.5	4.73%	-8.11%	4.49%	-10.87%
0.7	13.83%	-8.78%	5.65%	-8.97%

[5] https://www.gov.uk/guidance/environmental-permitting-air-dispersion-modelling-reports

As shown, higher surface roughness lengths result in higher annual mean concentrations but have a smaller effect on short-term concentrations. The use of a spatially varying surface roughness file results in a maximum annual mean concentration similar to that for a constant surface roughness between 0.3 - 0.5 m. The use of the spatially varying surface roughness length results in higher maximum short-term concentrations than any of the constant surface roughness lengths considered.

Due to the sensitivity of the maximum results to the choice of surface roughness length it is considered appropriate to use the spatially varying surface roughness file in the main model runs as this most accurately represents the variations in land use and surface roughness around the Facility.

6.2 Building parameters

ADMS 5.2 has a buildings effects module to account for the impact of buildings when it calculates the air flow and dispersion of pollutants from a source. The sensitivity of the results to the effect of buildings has been considered by running the model with the building presented in Table 23 and with no buildings at all.

The following parameters have been kept constant:

- Scenario – Proposed Facility;
- Grid – 10 x 10 km at 100 m resolution;
- Terrain file – included at 64 x 64 resolution;
- Dispersion site surface roughness – variable at 64 x 64 resolution;
- Meteorological site surface roughness – 0.2 m;
- Dispersion site Monin-Obukhov length – 30 m;
- Meteorological site Monin-Obukhov length – 10 m; and
- Meteorological data used – Teesside International Airport 2018.

The contribution of the Facility to the ground level concentrations of oxides of nitrogen at the point of maximum predicted concentration and maximum impacted receptor are presented in Table 25 for each scenario.

Table 25: Effect of Building

Scenario	Oxides of nitrogen PC (µg/m³)			
	Point of maximum impact		Maximum impacted receptor	
	Annual Mean	Max 1-hour mean	Annual Mean	Max 1-hour mean
Including building	**0.48**	**34.75**	**0.27**	**30.15**
Excluding building	0.47	34.75	0.27	30.15
% Change	-1.04%	0.00%	-0.03%	0.00%

As shown, modelling the presence of buildings results in very slightly higher annual mean concentrations at the point of maximum impact and the maximum impacted receptor, but has no effect on the maximum hourly concentration. This is expected as the building is only just slightly taller than 1/3 of the stack height. Although the effect of the building is small, the building has been included in the dispersion model as this is the most realistic scenario.

6.3 Terrain

The sensitivity of the results to the effect of terrain has been considered by running the model with and without the terrain file.

The following parameters have been kept constant:

- Scenario – Proposed Facility;
- Grid – 10 x 10 km at 100 m resolution;
- Buildings - included;
- Dispersion site surface roughness – variable at 64 x 64 resolution;
- Meteorological site surface roughness – 0.2 m;
- Dispersion site Monin-Obukhov length – 30 m;
- Meteorological site Monin-Obukhov length – 10 m; and
- Meteorological data used – Teesside International Airport 2018.

The contribution of the Proposed Facility to the ground level concentrations of oxides of nitrogen at the point of maximum predicted concentration and maximum impacted receptor are presented in Table 26 for each scenario.

Table 26: Effect of Terrain

Scenario	Oxides of nitrogen PC (µg/m³)			
	Point of maximum impact		Maximum impacted receptor	
	Annual mean	Max 1-hour mean	Annual mean	Max 1-hour mean
Including terrain	**0.48**	**34.75**	**0.27**	**30.15**
Excluding terrain	0.45	33.26	0.28	30.08
% Change	-5.25%	-4.29%	1.58%	-0.22%

As shown, modelling the effect of terrain has a small effect on the annual mean and maximum 1-hour concentrations. The main model runs have included the effect of complex terrain as this is the most realistic scenario.

6.4 Grid resolution

The sensitivity of the results to the grid resolution used has been considered by comparing the results with the nested grid (which has the finest resolution of 20 m close to the stacks, in the vicinity of the point of maximum impact) with a finer grid resolution of 10 m.

The following parameters were kept constant:

- Scenario – with CCS on lines 1-3, emissions from lines 4-5 included;
- Stack height – 70 m;
- Buildings - included;
- Terrain file – included at 64 x 64 resolution;
- Dispersion site surface roughness – variable at 64 x 64 resolution;
- Meteorological site surface roughness – 0.2 m;
- Dispersion site Monin-Obukhov length – 30 m;

- Meteorological site Monin-Obukhov length – 10 m; and
- Meteorological data used – Teesside International Airport 2018.

The contribution of the Facility to the ground level concentration of NOx at the point of maximum impact is presented in Table 27 for each scenario.

Table 27: Effect of Grid Resolution

Grid resolution used in model (m)	NOx PC (µg/m³)	
	Annual Mean	Max 1-hour mean
20 m	0.48	34.75
10 m	0.48	34.88
% change	0.01%	0.37%

As shown, the choice of grid resolution has a negligible effect on the maximum annual mean concentrations and short-term concentrations. The output grid resolution of 100 m is considered sufficiently fine to accurately capture the maximum predicted concentrations. The choice of grid resolution does not affect the impacts at the specific receptor points.

6.5 Operating below the design point

Dispersion modelling has been undertaken using the emission parameters based on the revised design point for the Facility. The Facility is operated as a commercial plant, so it is beneficial to operate at full capacity. If the Facility was operated below the design point, the volumetric flow rate and the exit velocity of the exhaust gases would reduce. The effect of this would be to decrease the quantity of pollutants emitted but also to reduce the buoyancy of the plume due to momentum. The reduction in buoyancy, which would lead to reduced dispersion, would be more than offset by the decrease in the quantity of pollutants being emitted, and the impact of the Facility when operating below the design point would be lower than compared to operating at the design point.

7 Model Validation and Uncertainty

The Environment Agency has requested that the level of uncertainty in the predictions is estimated. To do so, the results of the model validation documentation and the sensitivities have been considered, and the conservatism in the modelling has been reviewed.

7.1 Validation of ADMS model

7.1.1 Introduction

Dispersion modelling of process emission from the Facility was carried out using ADMS (version 5.2) developed by CERC.

This section of the report describes the model and explains why it is considered appropriate for modelling the impacts of the Facility.

7.1.2 Model description

ADMS is a new generation dispersion model which characterises the atmospheric boundary layer in terms of the atmospheric stability and the boundary layer height. In addition, the model uses a skewed Gaussian distribution for dispersion under convective conditions, to take into account the skewed nature of turbulence. The model also includes modules to take account of the effect of buildings and complex terrain.

Within ADMS, the FLOWSTAR module is used to generate a new flow and turbulence field based on the terrain. This simulates the changes to the movement of air in the horizontal and vertical direction as a result of the terrain features in that the air flow is simulated flowing above and around raised ground. This modified flow field is then used by the model to adjust the plume height and plume spread parameters calculated by the flat terrain model. The ADMS model can also handle cases of strongly stable flow using a separate plume impingement model.

The technical specification document for the complex terrain module[6] explains that *"terrain should have no more than moderate slopes (up to 1:3) although the model is useful even when this criterion is not met (say up to 1:2)"*.

The surroundings of the Facility are generally flat or gently sloping, with only a few areas where the gradient is greater than 1:10 and no areas where it is greater than 1:3. CERC notes that during very low wind stable conditions in hilly terrain, horizontal gradients in density can cause katabatic (downslope) winds, which may influence the background flow in deep valleys[7]. These effects are not specifically accounted for in ADMS. However, the local area does not include such valleys and as such this limitation of the model is not relevant to this project.

7.1.3 Model validation

CERC validates its models against available measured data obtained from real world situations, field campaigns and wind tunnel experiments. The validation studies are published on the CERC website[8]. Not all of the validation studies are for settings similar to the Facility study area (flat

[6] CERC, P14/01S/17 Complex Terrain Module, March 2020

[7] CERC, Note 110 Temperature Inversions in ADMS, 20 April 2017

[8] https://www.cerc.co.uk/environmental-software/model-validation.html

and/or gently sloping terrain. There are two validation studies that are considered to be in locations similar to the study area. These are detailed in Table 28.

Table 28: Model Validation Studies

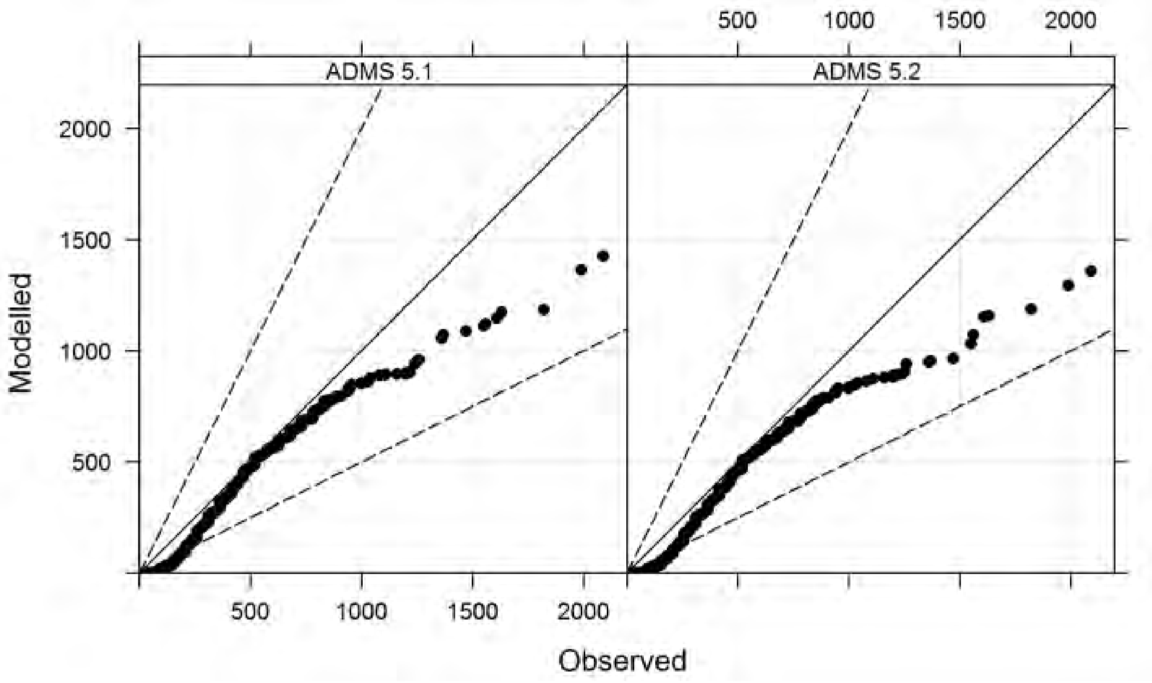
Study	Notes
Baldwin Power Plant	Characterised as "complex terrain below the stack height". Complex terrain is included in model for the Facility but it does not rise above the stack height within the study area.
Kincaid, Indianapolis and Prairie Grass experiments	Kincaid – flat farmland with lakes Indianapolis – flat land, mixed industrial/commercial/urban. Although the model for the Facility includes terrain effects, these are relatively minor (see section 6.3). Prairie Grass experiment – ground level release, not relevant to Facility study area.

The validation studies include scatter plots, quantile-quantile plots, and a comparison between the observed and modelled maximum and robust highest concentration (Baldwin Power Station only).

- The scatter plots compare predicted and measured concentrations at a particular location at a particular time.
- The quantile-quantile plots compare the distribution of predicted and measured concentrations during the period having abandoned the (x,t) pairing – i.e. comparing the first highest concentration from the monitored with the first highest concentration predicted.
- The highest concentration is subject to extreme variations. Therefore, the robust highest concentration (RHC) is used due to its stability which is based on a tail exponential fit to the upper end of the distribution. The RHC is strongly related to the average and standard deviation.

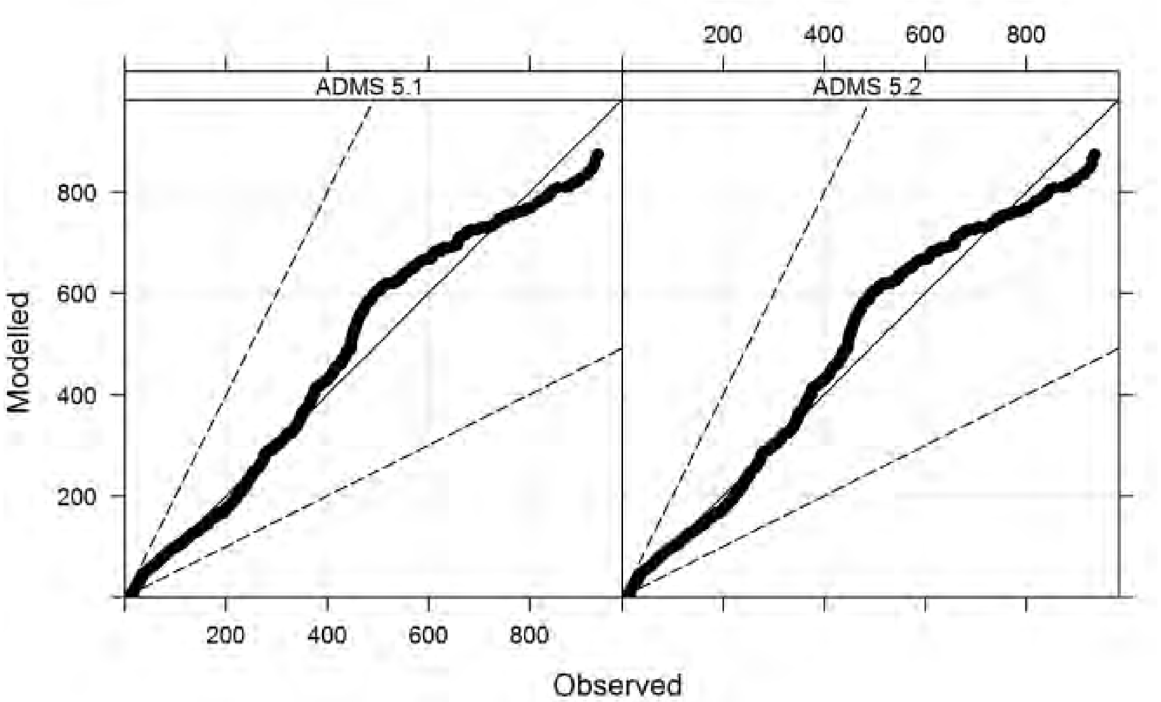
The most useful visual aid for evaluating model performance is the quantile-quantile plot which shows how the model performs across the full range of modelled and observed concentrations. The quantile-quantile plots for each validation study are shown below.

Quantile – Quantile Plot – Baldwin Power Station



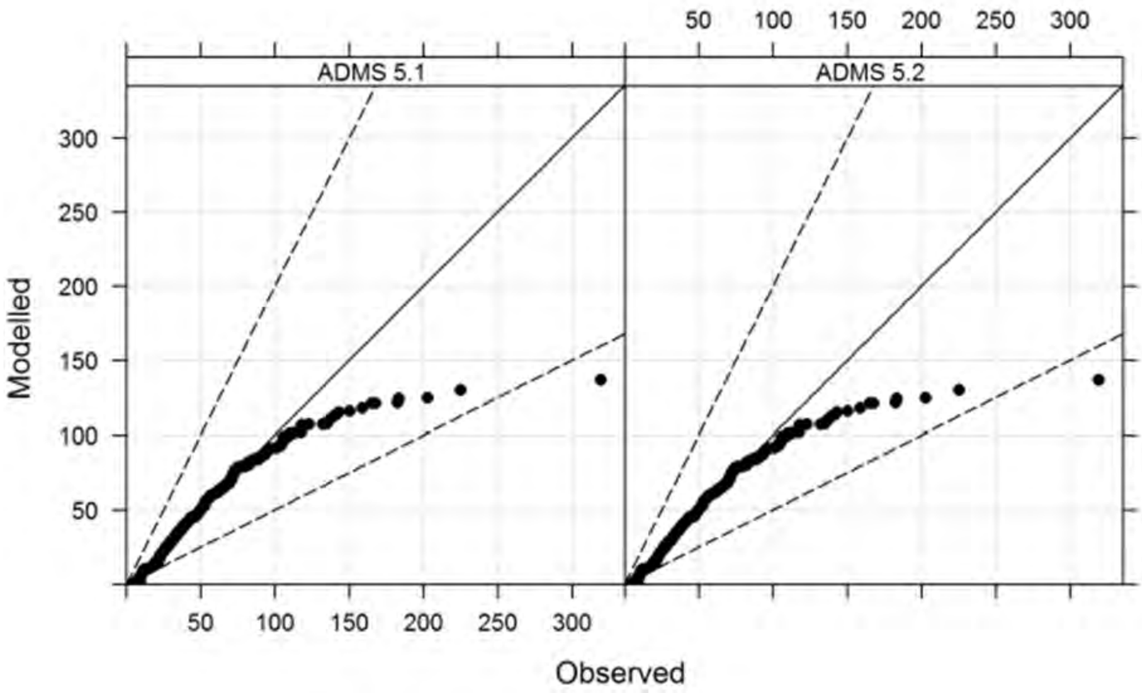
Source: CERC, ADMS 5 Complex Terrain Validation Baldwin Power Plant, November 2016

Quantile – Quantile Plot – Indianapolis



Source: CERC, ADMS 5 Flat Terrain Validation Kincaid, Indianapolis and Prairie Grass, November 2016

Quantile – Quantile Plot – Kincaid



Source: CERC, ADMS 5 Flat Terrain Validation Kincaid, Indianapolis and Prairie Grass, November 2016

These plots show that at the most common (median) concentrations the modelled and observed concentrations are very similar, giving high confidence in annual mean concentrations. However, the maximum concentrations tended to be under-predicted in two out of the three studies (Baldwin and Kincaid), albeit these are based on a very small sample size.

For the Baldwin Power Plant validation is carried out against sulphur dioxide (SO_2) concentrations. In the validation document[9] CERC explain that there are issues with using SO_2 as a tracer which include:

- The limitations of detection are usually of the order of 16 µg/m^3, and concentrations below these are set to one-half of the limit. This leads to considerable inaccuracy when modelled concentrations are low.
- SO_2 is released from other sources. If estimates of these background concentrations are not available, then the model will underestimate concentrations, particularly long-term averages.

CERC does not report the modelled long-term or annual average concentration against the observed concentration and has only reported the RHC for the Baldwin Power Station study. This is reported for 1 hour, 3 hour and 24 hour averages. The ratio of mean to observed concentrations for the RHC varies from 0.65 to 0.79 across these averaging periods, indicating that the model may be under-estimating the very highest concentrations by up to 35%.

Taking the above into account, it is likely that annual mean concentrations are modelled with a high degree of accuracy. However, the extreme maximum concentrations are less certain, subject to up to 35% uncertainty based on the Baldwin validation study, and potentially over 50% based on the quantile-quantile plot for the Kincaid validation study.

[9] CERC, ADMS 5 Complex Terrain Validation Baldwin Power Plant, November 2016

7.2 Uncertainty

The validation documentation shows that the levels of uncertainty in the ADMS model with respect to the peak predicted concentrations are typically within 35-50% of the hourly and daily concentrations, with accuracy over longer time frames shown to be much greater than this.

The sensitivity analysis in section 6 shows that varying surface roughness and terrain parameters leads to changes in the peak results of up to around 15%, which is slightly smaller than the inherent uncertainty in the model shown in the validation studies.

Variations in weather data are more complex and feed into the inter-annual variability discussed below.

In order to allow for modelling uncertainty, this DMA includes a number of conservative assumptions. These are explained and quantified in this section.

7.2.1 Interannual variability

The detailed results tables presented in the DMA included the breakdown of the peak concentration using each year of meteorological data. The maximum predicted impact over the 5-years of data was then used as the basis of the assessment.

The interannual variability in the data has been presented in appendix B. The following table provides a breakdown of the range of the predicted impacts at the point of maximum impact for each averaging period.

Table 29: Interannual Variability

Averaging time	Impact as percentage of maximum (Proposed Facility)	
	Minimum	Average
Annual mean	92%	95%
Max 1-hour	82%	93%
99.79%ile 1-hour	82%	90%
99.73%ile 1-hour	81%	89%
99.9%ile 15-min	85%	94%
Max 24-hour	82%	93%

For the point of maximum impact, the annual average over all five years of weather data is 95% of the highest year, and the minimum is 92% of the highest year. This suggests that using the peak year introduces a conservatism of around 5%. There is slightly more inter-annual variability for shorter-term impacts, where generally 5-10% conservatism is introduced.

7.2.2 Plant availability

The results are based on the assumption that the Facility would operate for 100% of the time. This is a very conservative assumption. The Facility will be off for periods of maintenance with annual availability expected to be around 8,000 hours (91%). This level of availability is likely to remains broadly consistent in the future.

7.2.3 Emission limits

The results are based on the assumption that the Facility will operate at the long term emission limits for 100% of the time. However, the Facility will be designed to operate at a safety margin of at least 10% below the ELVs. Based on the performance of other modern plants in the UK, it is expected that for some pollutants the Facility will operate at a very low percentage of the ELVs.

7.2.4 Short term impacts

For short term impacts it has been assumed that the period when the Facility would need to operate at the half-hourly ELV would occur for an entire hour, during the worst-case weather conditions for dispersion. This is a highly conservative assumption. In order to achieve the daily ELV, the Facility is operated to achieve the daily ELV for each hour, with only occasional emissions above this.

Furthermore, the half-hourly ELV is that from the IED. The WI BAT Conclusions introduce a lower daily limit for oxides of nitrogen and sulphur dioxide, which mean that the Facility will generally be operating at lower emission levels in the future than it does at present, and so short term excursions above the daily ELV are likely to be lower. The IED half-hourly limit for oxides of nitrogen is 2 times the IED daily limit, whilst the half-hourly limit for sulphur dioxide is 4 times the daily limit. Therefore, it is unlikely that peaks in short term emissions would be this high given that a lower daily ELV needs to be achieved.

7.3 Overall effect on results

The conservative assumptions explained above mean that the overall impacts presented in this DMA will be overestimates.

1. Annual mean impacts are overstated by around 10% due to plant availability, by 5-10% when inter-annual variability is considered and by at least 10% when allowing for operation below the emission limits. This means that, overall, the annual mean impacts in this DMA have inbuilt conservatism of at least 25-30%.
2. For short term impacts selecting the worst case weather conditions across all five years of weather data introduces conservatism of 5-10%, and assuming operation at the short term ELVs introduces conservatism of as much as 50-70%.
3. The validation documentation shows that the level of uncertainty in the model are on average within 35-50% of the hourly and daily concentrations, with accuracy over long time frames shown to be higher than this.
4. The sensitivity analysis shows that variations in modelling assumptions leads to changes in the peak concentrations of up to 15%.

Therefore, it is considered that the results presented in this DMA are robust as the inbuilt conservatism is of a similar order to the uncertainty in the modelling for annual mean and short-term concentrations.

8 Impact on Human Health

8.1 Screening criteria

The Air Emissions Guidance states that to screen out 'insignificant' process contributions:

- the long-term process contribution must be less than 1% of the long-term environmental standard; and
- the short-term process contribution must be less than 10% of the short-term environmental standard.

Consultation with the EA has confirmed that if the above criteria are achieved, it can be concluded that "it is not likely that emissions would lead to significant environmental impacts" and the process contributions can be screened out. These screening criteria have been applied to the change in process contribution as a result of the EP variation.

The long-term 1% process contribution threshold is based on the judgement that:

- it is unlikely that an emission at this level will make a significant contribution to air quality; and
- the threshold provides a substantial safety margin to protect health and the environment.

The short-term 10% process contribution threshold is based on the judgement that:

- spatial and temporal conditions mean that short-term process contributions are transient and limited in comparison with long-term process contributions; and
- the threshold provides a substantial safety margin to protect health and the environment.

If the change in process contributions cannot be screened out, assessment of the following should be undertaken:

- the predicted environmental concentration (PEC) at the point of maximum impact – defined as the process contribution plus the baseline concentration; and
- the- change in process contribution and PEC at areas of public exposure.

In these cases, consultation with the EA has confirmed that if the long-term PEC is below 70% of the AQAL, or the change in short-term process contribution is less than 20% of the headroom[10] it can be concluded that "there is little risk of the PEC exceeding the AQAL", and the impact can be considered to be 'not significant'.

The EA guidance document 'Guidance on assessing group 3 metals stack emissions from incinerators – V.4 June 2016' ('EA metals guidance') states that where the process contribution for any metal exceeds 1% of the long term or 10% of the short-term environmental standard (in this case the AQAL), this is considered to have potential for significant pollution. Where the process contribution exceeds these criteria, the PEC should be compared to the AQAL. The PEC can be screened out if is less than the AQAL. Where the impact is within these parameters it can be concluded that there is no risk of exceeding the AQAL.

8.2 Results

Table 30 and Table 31 present the results of the dispersion modelling of process emissions at the point of maximum impact. The results show the impact of the Permitted Facility, the impact of the Proposed Facility, and the change in impact. This is a summary of the maximum impact over 5 years.

[10] Calculated as the AQAL minus twice the long-term background concentration.

Detailed results for each of the 5 years of weather data are presented in Appendix A. The results are presented as the maximum predicted concentration based on the following:

- 5 years of weather data 2017 to 2021 from Teesside International Airport meteorological recording station;
- Assumes operation of all lines at the long term ELVs for 100% of the year;
- Assumes operation of all lines at the short term ELVs during the worst-case conditions for dispersion of emissions (Table 31 only).
- EA's worst case 70% long-term and 35% short-term conversion of NOx to nitrogen dioxide;
- The entire VOC emissions are assumed to consist of either benzene or 1,3-butadiene; and
- Cadmium is released at the combined ELV for cadmium and thallium;

The baseline concentrations are taken from the summary of baseline conditions contained in section 3. For short term averaging periods, the baseline concentration has been assumed to be twice the long-term ambient concentration following the Air Emissions Guidance methodology.

In these and subsequent results tables, PCs that cannot be screened out as 'insignificant' are highlighted. If the PC cannot be screened out and the PEC also cannot be screened out, this has also been highlighted. Where the PC cannot be screened out as 'insignificant', further analysis has been undertaken.

Table 30: Dispersion Modelling Results – Point of Maximum Impact - Daily ELVs

Pollutant	Quantity	Units	AQAL	Bg conc.	Permitted Facility		Proposed Facility				Change	
					Max PC	Max PC as % of AQAL	Max PC	Max PC as % of AQAL	PEC	PEC as % of AQAL	in PC	in PC as % of AQAL
Nitrogen dioxide	Annual mean	µg/m³	40	28.68	0.37	0.93%	0.34	0.84%	29.02	72.54%	-0.04	-0.09%
	99.79th %ile hourly means	µg/m³	200	57.36	6.39	3.19%	5.78	2.89%	63.14	31.57%	-0.61	-0.30%
Sulphur dioxide	99.18th %ile daily means	µg/m³	125	4.00	1.13	0.90%	1.01	0.81%	5.01	4.01%	-0.12	-0.09%
	99.73rd %ile hourly means	µg/m³	350	4.00	4.30	1.23%	3.88	1.11%	7.88	2.25%	-0.42	-0.12%
	99.9th %ile 15 min. means	µg/m³	266	4.00	5.63	2.12%	5.01	1.88%	9.01	3.39%	-0.62	-0.23%
PM_{10}	Annual mean	µg/m³	40	18.00	0.03	0.07%	0.02	0.06%	18.02	45.06%	0.00	-0.01%
	90.41st %ile daily means	µg/m³	50	36.00	0.10	0.20%	0.09	0.18%	36.09	72.18%	-0.01	-0.02%
$PM_{2.5}$	Annual mean	µg/m³	20	10.00	0.03	0.13%	0.02	0.12%	10.02	50.12%	-0.003	-0.01%
Carbon monoxide	8 hour running mean	µg/m³	10,000	764	5.75	0.06%	5.14	0.05%	769.14	7.69%	-0.61	-0.01%
	Hourly mean	µg/m³	30,000	764	9.57	0.03%	8.68	0.03%	772.68	2.58%	-0.89	0.00%
Hydrogen chloride	Hourly mean	µg/m³	750	1.42	1.91	0.26%	1.74	0.23%	3.16	0.42%	-0.18	-0.02%
Hydrogen fluoride	Annual mean	µg/m³	16	2.35	0.003	0.02%	0.002	0.01%	2.35	14.70%	0.00	-0.002%
	Hourly mean	µg/m³	160	4.70	0.19	0.12%	0.17	0.11%	4.87	3.05%	-0.02	-0.01%
Ammonia	Annual mean(1)	µg/m³	180	3.40	0.02	0.01%	0.02	0.01%	3.42	1.90%	-0.002	-0.001%

Pollutant	Quantity	Units	AQAL	Bg conc.	Permitted Facility		Proposed Facility				Change	
					Max PC	Max PC as % of AQAL	Max PC	Max PC as % of AQAL	PEC	PEC as % of AQAL	in PC	in PC as % of AQAL
	Hourly mean[2]	µg/m³	2,500	6.80	1.91	0.08%	1.74	0.07%	8.54	0.34%	-0.18	-0.01%
VOCs (as benzene)	Annual mean	µg/m³	5	1.10	0.03	0.53%	0.02	0.48%	1.12	22.48%	-0.003	-0.05%
	Daily mean	µg/m³	30	2.20	0.31	1.02%	0.27	0.92%	2.47	8.25%	-0.03	-0.11%
VOCs (as 1,3-butadiene)	Annual mean	µg/m³	2.25	0.32	0.03	**1.18%**	0.02	**1.06%**	0.34	15.29%	-0.003	-0.11%
Mercury	Annual mean	ng/m³	250	2.10	0.09	0.04%	0.12	0.05%	2.22	0.89%	0.03	0.01%
	Hourly mean	ng/m³	7,500	4.20	6.38	0.09%	8.68	0.12%	12.88	0.17%	2.30	0.03%
Cadmium	Annual mean	ng/m³	5	0.12	0.09	**1.76%**	0.12	**2.39%**	0.24	4.79%	0.03	0.63%
PAHs	Annual mean	pg/m³	250	180	0.53	0.21%	0.48	0.19%	180.48	72.19%	-0.05	-0.02%
Dioxins	Annual mean	fg/m³	-	32.99	0.18	-	0.24	-	33.23	-	0.06	-
PCBs	Annual mean	ng/m³	200	0.13	0.01	0.01%	0.01	0.01%	0.14	0.07%	-0.001	-0.001%
	Hourly mean	ng/m³	6,000	0.26	0.96	0.02%	0.87	0.01%	1.13	0.02%	-0.09	-0.001%
Other metals	Annual mean	ng/m³	-	-	0.88	-	1.20	-	-	-	0.32	-
	Daily mean	ng/m³	-	-	10.24	-	13.73	-	-	-	3.49	-
	Hourly mean	ng/m³	-	-	63.82	-	86.83	-	-	-	23.01	-

Notes:

All assessment is based on the maximum PC using all 5 years of weather data. Assumes the Permitted and Proposed Facility operate for 100% of the time at the daily ELVs.

(1) Assumes ammonia emissions as the monthly ELV.

(2) Assumes ammonia emissions as the daily ELV.

Table 31: Dispersion Modelling Results – Point of Maximum Impact - Short-Term ELVs (Proposed Facility Only)

Pollutant	Quantity	Units	AQAL	Bg conc.	Proposed Facility			
					Max PC	Max PC as % of AQAL	PEC	PEC as % of AQAL
Nitrogen dioxide	99.79th %ile of hourly means	µg/m³	200	57.36	11.55	5.78%	68.91	34.46%
Sulphur dioxide	99.73rd %ile of hourly means	µg/m³	350	4.00	15.53	4.44%	19.53	5.58%
	99.9th %ile of 15 min. means	µg/m³	266	4.00	20.05	7.54%	24.05	9.04%
Carbon monoxide	8 hour running mean	µg/m³	10,000	764	15.43	0.15%	779.43	7.79%
	Hourly mean	µg/m³	30,000	764	26.05	0.09%	790.05	2.63%
Hydrogen chloride	Hourly mean	µg/m³	750	1.42	10.42	1.39%	11.84	1.58%
Hydrogen fluoride	Hourly mean	µg/m³	160	4.70	0.69	0.43%	5.39	3.37%

Notes:
All assessment is based on the maximum PC using all 5 years of weather data.
Assumes the Proposed Facility operates for 100% of the time at the half-hourly ELVs

As shown, the Proposed Facility has a lower impact than the Permitted Facility for all pollutants and averaging periods, except for cadmium, mercury, group 3 metals, and dioxins, for which the pollutant release rate from the Proposed Facility is higher than that of the Permitted Facility. This is because of the higher ELV for these pollutants for incinerators than co-incinerators (when the change in reference oxygen content from 6% to 11% is taken into account). In addition, varying the EP to regulate the Facility as an incinerator introduces short-term emission limits for some pollutants. There is no AQAL set for dioxins, so the total intake has been assessed separately in the Dioxin Pathway Intake Assessment submitted with the EP variation application.

The change in impact between the Permitted and Proposed Facility is less than 10% of the short-term AQAL and less than 1% of the annual mean AQAL for all pollutants considered and can be screened out as 'insignificant' irrespective of the PEC in accordance with the Air Emissions Guidance.

In addition, the total impact of the Proposed Facility is less than 10% of the short-term AQAL and less than 1% of the annual mean AQAL for all pollutants considered, and can be screened out as 'insignificant' irrespective of the PEC, with the exception of the of the following:

- Annual mean VOCs as 1,3-butadiene; and
- Annual mean cadmium.

Further analysis of these impacts at areas of relevant exposure has been undertaken to define the significance of annual mean impacts.

8.3 Further analysis – annual mean impacts

Detailed results for those pollutants for which the annual mean PC from the Proposed Facility cannot be screened out as 'insignificant' are presented in Table 32 and Table 33 for 1,3-butadiene and cadmium respectively. The results are based on the conservative assumptions that all VOCs consist of 1,3-butadiene, and cadmium is emitted at 100% of the combined cadmium and thallium ELV.

Table 32: Annual Mean 1,3-Butadiene at Receptor Locations

Receptor	Permitted Facility PC		Proposed Facility PC		Proposed Facility PEC		Change	
	µg/m³	as % of AQAL	µg/m³	as % of AQAL	µg/m³	as % of AQAL	µg/m³	as % of AQAL
R1	0.006	0.28%	0.006	0.25%	0.33	14.48%	-0.0006	-0.03%
R2	0.005	0.23%	0.005	0.21%	0.32	14.43%	-0.0005	-0.02%
R3	0.017	0.76%	0.015	0.68%	0.34	14.90%	-0.0018	-0.08%
R4	0.011	0.51%	0.010	0.45%	0.33	14.67%	-0.0012	-0.05%
R5	0.004	0.19%	0.004	0.17%	0.32	14.39%	-0.0005	-0.02%
R6	0.010	0.42%	0.009	0.38%	0.33	14.60%	-0.0010	-0.05%
R7	0.007	0.33%	0.007	0.29%	0.33	14.51%	-0.0008	-0.03%

Table 33: Annual Mean Cadmium at Receptor Locations

Receptor	Permitted Facility PC		Proposed Facility PC		Proposed Facility PEC		Change	
	µg/m³	as % of AQAL	µg/m³	as % of AQAL	µg/m³	as % of AQAL	µg/m³	as % of AQAL
R1	0.021	0.42%	0.028	0.57%	0.148	2.97%	0.007	0.15%
R2	0.017	0.35%	0.023	0.46%	0.143	2.86%	0.006	0.12%
R3	0.057	**1.14%**	0.077	**1.53%**	0.197	3.93%	0.019	0.39%
R4	0.038	0.76%	0.051	**1.02%**	0.171	3.42%	0.013	0.26%
R5	0.014	0.28%	0.019	0.38%	0.139	2.78%	0.005	0.10%
R6	0.032	0.64%	0.043	0.85%	0.163	3.25%	0.011	0.21%
R7	0.024	0.49%	0.033	0.66%	0.153	3.06%	0.008	0.17%

As shown, the change in PC at all receptor locations is less than 1% of the AQAL and is 'insignificant' for all pollutants. Consideration has also been given to the overall impact of the Proposed Facility. The PC of 1,3-butadiene from the Proposed Facility is less than 1% of the AQAL and is 'insignificant' at all receptor locations. The PC of cadmium exceeds 1% at two receptor locations (R3 and R4). However, the PEC is less than 4% of the AQAL. As this is well below 70% of the AQAL, the effect is 'not significant'.

Data collected by the Environmental Services Association to report to the European Waste Incineration BREF working group shows that the average cadmium concentration recorded from UK plants equipped with bag filters was 1.6 µg/Nm³ (or 3.2% of the ELV of 0.02 mg/Nm³), the highest recorded concentration of cadmium and thallium was 14 µg/Nm³ (or 28% of the ELV) and only three lines recorded concentrations higher than 10 µg/Nm³ (or 20% of the ELV of 0.05 mg/Nm³). If it is assumed that the Proposed Facility emits cadmium at the highest recorded value from the BREF (28% of the ELV), which is still a conservative worst-case assumption, the PC at the point of maximum impact would be 0.67% of the ELV, so the PC at the point of maximum impact and at all receptor locations would screen out as 'insignificant'.

The following plot files showing the Permitted and Proposed Development PC of all pollutants that cannot be screened out are presented in Appendix A:

- Figure 9: Annual Mean 1,3-Butadiene; and
- Figure 10: Annual Mean Cadmium.

8.4 Heavy metals – at the point of maximum impact

The assessment of the impact of heavy metals has been undertaken for the Permitted Facility; the Proposed Facility; and also the change in impact as a result of the EP variation.

The results tables below (Table 34 to Table 39) detail the following:

1. The PC and PEC for each metal, assuming that each metal is released at the combined long-term metal ELV set out in the Waste Incineration BREF (stage 1 screening); and

2. The PC and PEC for metal, assuming that each metal is released at the maximum monitored concentration presented in the EA's metals guidance[11].

[11] Environment Agency, June 2016, Guidance on assessing group 3 metal stack emissions from incinerators (V.4)

Table 34: Long-Term Metals Results at Point of Maximum Impact – Permitted Facility

Metal	AQAL	Baseline conc.	Metals emitted at combined metal limit				Metal as % of ELV (1)	Each metal emitted at the maximum concentration from the EA metals guidance document			
			PC		PEC			PC		PEC	
	ng/m³	ng/m³	ng/m³	as % AQAL	ng/m³	as % AQAL		ng/m³	as % AQAL	ng/m³	as % AQAL
Arsenic	6	0.39	0.88	**14.69%**	1.27	21.19%	5.0%	0.04	0.73%	0.43	7.23%
Antimony	5,000	1.30	0.88	0.02%	2.18	0.04%	2.3%	0.02	0.0004%	1.32	0.026%
Chromium	5,000	1.60	0.88	0.02%	2.48	0.05%	18.4%	0.16	0.003%	1.76	0.04%
Chromium (VI)	0.25	0.32	0.88	**352.6%**	1.20	**480.6%**	0.026%	0.0002	0.09%	0.32	128.09%
Cobalt	-	0.03	0.88	-	0.91	-	1.1%	0.01	-	0.04	-
Copper	10,000	2.20	0.88	0.01%	3.08	0.03%	5.8%	0.05	0.001%	2.25	0.02%
Lead	250	4.30	0.88	0.35%	5.18	2.07%	10.1%	0.09	0.04%	4.39	1.76%
Manganese	150	4.10	0.88	0.59%	4.98	3.32%	12.0%	0.11	0.07%	4.21	2.80%
Nickel	20	0.51	0.88	**4.41%**	1.39	6.96%	44.0%	0.39	**1.94%**	0.90	4.49%
Vanadium	-	0.65	0.88	-	1.53	-	1.2%	0.01	-	0.66	-

Notes:

(1) Metal as maximum percentage of the group 3 BAT-AEL, recalculated from the data presented in EA's metals guidance document (V.4) Table A1.

Table 35: Long-Term Metals Results at Point of Maximum Impact – Proposed Facility

Metal	AQAL	Baseline conc.	Metals emitted at combined metal limit				Metal as % of ELV [(1)]	Each metal emitted at the maximum concentration from the EA metals guidance document			
			PC		PEC			PC		PEC	
	ng/m³	ng/m³	ng/m³	as % AQAL	ng/m³	as % AQAL		ng/m³	as % AQAL	ng/m³	as % AQAL
Arsenic	6	0.39	1.20	**19.95%**	1.59	26.45%	5.0%	0.06	**1.00%**	0.45	7.50%
Antimony	5,000	1.30	1.20	0.02%	2.50	0.05%	2.3%	0.03	0.001%	1.33	0.03%
Chromium	5,000	1.60	1.20	0.02%	2.80	0.06%	18.4%	0.22	0.004%	1.82	0.04%
Chromium (VI)	0.25	0.32	1.20	**478.7%**	1.52	**606.7%**	0.026%	0.00	0.12%	0.32	128.12%
Cobalt	-	0.03	1.20	-	1.23	-	1.1%	0.01	-	0.04	-
Copper	10,000	2.20	1.20	0.01%	3.40	0.03%	5.8%	0.07	0.001%	2.27	0.02%
Lead	250	4.30	1.20	0.48%	5.50	2.20%	10.1%	0.12	0.05%	4.42	1.77%
Manganese	150	4.10	1.20	0.80%	5.30	3.53%	12.0%	0.14	0.10%	4.24	2.83%
Nickel	20	0.51	1.20	**5.98%**	1.71	8.53%	44.0%	0.53	**2.63%**	1.04	5.18%
Vanadium	-	0.65	1.20	-	1.85	-	1.2%	0.01	-	0.66	-

Notes:

(1) Metal as maximum percentage of the group 3 BAT-AEL, recalculated from the data presented in EA's metals guidance document (V.4) Table A1.

Table 36: Long-Term Metals Results at Point of Maximum Impact – Change in Impact

Metal	AQAL	Baseline conc.	Metals emitted at combined metal limit				Metal as % of ELV (1)	Each metal emitted at the maximum concentration from the EA metals guidance document			
			Change in PC		PEC			Change in PC		PEC	
	ng/m³	ng/m³	ng/m³	as % AQAL	ng/m³	as % AQAL		ng/m³	as % AQAL	ng/m³	as % AQAL
Arsenic	6	0.39	0.32	**5.26%**	1.59	26.45%	5.0%	0.02	0.26%	0.45	7.50%
Antimony	5,000	1.30	0.32	0.01%	2.50	0.05%	2.3%	0.01	0.0001%	1.33	0.027%
Chromium	5,000	1.60	0.32	0.01%	2.80	0.06%	18.4%	0.06	0.001%	1.82	0.04%
Chromium (VI)	0.25	0.32	0.32	**126.1%**	1.52	**606.7%**	0.026%	0.0001	0.03%	0.32	128.12%
Cobalt	-	0.03	0.32	-	1.23	-	1.1%	0.004	-	0.04	-
Copper	10,000	2.20	0.32	0.003%	3.40	0.03%	5.8%	0.02	0.0002%	2.27	0.02%
Lead	250	4.30	0.32	0.13%	5.50	2.20%	10.1%	0.03	0.01%	4.42	1.77%
Manganese	150	4.10	0.32	0.21%	5.30	3.53%	12.0%	0.04	0.03%	4.24	2.83%
Nickel	20	0.51	0.32	**1.58%**	1.71	8.53%	44.0%	0.14	0.69%	1.04	5.18%
Vanadium	-	0.65	0.32	-	1.85	-	1.2%	0.004	-	0.66	-

Notes:
(1) Metal as maximum percentage of the group 3 BAT-AEL, recalculated from the data presented in EA's metals guidance document (V.4) Table A1.

Table 37: Short-Term Metals Results at Point of Maximum Impact – Permitted Facility

Metal	AQAL	Baseline conc.	Metals emitted at combined metal limit				Metal as % of ELV [(1)]	Each metal emitted at the maximum concentration from the EA metals guidance document			
			PC		PEC			PC		PEC	
	ng/m³	ng/m³	ng/m³	as % AQAL	ng/m³	as % AQAL		ng/m³	as % AQAL	ng/m³	as % AQAL
Arsenic	-	0.78	63.82	-	64.60	-	5.0%	3.19	-	3.97	-
Antimony	150,000	2.60	63.82	0.04%	66.42	0.04%	2.3%	1.47	0.001%	4.07	0.003%
Chromium	150,000	3.20	63.82	0.04%	67.02	0.04%	18.4%	11.74	0.01%	14.94	0.01%
Chromium (VI)	-	0.64	63.82	-	64.46	-	0.026%	0.02	-	0.66	-
Cobalt	-	0.06	63.82	-	63.88	-	1.1%	0.71	-	0.77	-
Copper	200,000	4.40	63.82	0.03%	68.22	0.03%	5.8%	3.70	0.002%	8.10	0.004%
Lead	-	8.60	63.82	-	72.42	-	10.1%	6.42	-	15.02	-
Manganese	1,500,000	8.20	63.82	0.004%	72.02	0.00%	12.0%	7.66	0.001%	15.86	0.001%
Nickel	-	1.02	63.82	-	64.84	-	44.0%	28.08	-	29.10	-
Vanadium (daily mean)	1,000	1.30	10.24	1.02%	11.54	1.15%	1.2%	0.12	0.012%	1.42	0.14%

Notes:
(1) Metal as maximum percentage of the group 3 BAT-AEL, recalculated from the data as presented in EA's metals guidance document (V.4) Table A1.

Table 38: Short-Term Metals Results at Point of Maximum Impact – Proposed Facility

Metal	AQAL	Baseline conc.	Metals emitted at combined metal limit				Metal as % of ELV (1)	Each metal emitted at the maximum concentration from the EA metals guidance document			
			PC		PEC			PC		PEC	
	ng/m³	ng/m³	ng/m³	as % AQAL	ng/m³	as % AQAL		ng/m³	as % AQAL	ng/m³	as % AQAL
Arsenic	-	0.78	86.83	-	87.61	-	5.0%	4.34	-	5.12	-
Antimony	150,000	2.60	86.83	0.06%	89.43	0.06%	2.3%	2.00	0.001%	4.60	0.003%
Chromium	150,000	3.20	86.83	0.06%	90.03	0.06%	18.4%	15.98	0.01%	19.18	0.01%
Chromium (VI)	-	0.64	86.83	-	87.47	-	0.026%	0.02	-	0.66	-
Cobalt	-	0.06	86.83	-	86.89	-	1.1%	0.97	-	1.03	-
Copper	200,000	4.40	86.83	0.04%	91.23	0.05%	5.8%	5.04	0.003%	9.44	0.005%
Lead	-	8.60	86.83	-	95.43	-	10.1%	8.74	-	17.34	-
Manganese	1,500,000	8.20	86.83	0.01%	95.03	0.01%	12.0%	10.42	0.001%	18.62	0.001%
Nickel	-	1.02	86.83	-	87.85	-	44.0%	38.21	-	39.23	-
Vanadium (daily mean)	1,000	1.30	13.73	1.37%	15.03	1.50%	1.2%	0.16	0.016%	1.46	0.15%

Notes:
(1) Metal as maximum percentage of the group 3 BAT-AEL, recalculated from the data as presented in EA's metals guidance document (V.4) Table A1.

Table 39: Short-Term Metals Results at Point of Maximum Impact – Change in Impact

Metal	AQAL	Baseline conc.	Metals emitted at combined metal limit				Metal as % of ELV [(1)]	Each metal emitted at the maximum concentration from the EA metals guidance document			
			Change in PC		PEC			Change in PC		PEC	
	ng/m³	ng/m³	ng/m³	as % AQAL	ng/m³	as % AQAL		ng/m³	as % AQAL	ng/m³	as % AQAL
Arsenic	-	0.78	23.01	-	87.61	-	5.0%	1.15	-	5.12	-
Antimony	150,000	2.60	23.01	0.02%	89.43	0.06%	2.3%	0.53	0.0004%	4.60	0.003%
Chromium	150,000	3.20	23.01	0.02%	90.03	0.06%	18.4%	4.23	0.003%	19.18	0.01%
Chromium (VI)	-	0.64	23.01	-	87.47	-	0.026%	0.01	-	0.66	-
Cobalt	-	0.06	23.01	-	86.89	-	1.1%	0.26	-	1.03	-
Copper	200,000	4.40	23.01	0.01%	91.23	0.05%	5.8%	1.33	0.001%	9.44	0.005%
Lead	-	8.60	23.01	-	95.43	-	10.1%	2.31	-	17.34	-
Manganese	1,500,000	8.20	23.01	0.002%	95.03	0.01%	12.0%	2.76	0.0002%	18.62	0.001%
Nickel	-	1.02	23.01	-	87.85	-	44.0%	10.12	-	39.23	-
Vanadium (daily mean)	1,000	1.30	3.49	0.35%	15.03	1.50%	1.2%	0.04	0.004%	1.46	0.15%

Notes:
(1) Metal as maximum percentage of the group 3 BAT-AEL, recalculated from the data as presented in EA's metals guidance document (V.4) Table A1.

If it is assumed that the entire emissions of metals consist of only one metal, the impact of the Proposed Facility is less than 1% of the long-term and less than 10% of the short-term AQAL, with the exception of annual mean impacts of arsenic, chromium (VI), and nickel, which have been highlighted. The PEC is only predicted to exceed the AQALs for annual mean chromium (VI) using this worst-case screening assumption.

If it is assumed that the Proposed Facility would emit metals at the maximum concentration from the EA's metals guidance document, the PC is below 1% of the long term and 10% of the short term AQAL for all pollutants with the exception of annual mean arsenic and nickel. However, the annual mean PEC is well below the AQAL for both arsenic and nickel. Therefore, the impact of emissions of these metals can be screened out and is considered to be not significant. In addition, the PEC of chromium (VI) exceeds the AQAL but this due to the high assumed baseline concentration (20% of total chromium, in lieu of any direct monitoring of chromium (VI)). The contribution from the Proposed Facility is less than 1% of the AQAL and can be screened out as 'insignificant'.

Consideration has also been given to the change in impact. Table 39 shows that, If it is assumed that the Proposed Facility would emit metals at the maximum concentration from the EA's metals guidance document, the change in long-term PC is less than 1% and the change in short-term PC is less than 10% for all pollutants. Therefore, the change in impact of emissions of metals can be screened out as 'insignificant'.

9 Impact at Ecological Receptors

9.1 Screening

The Air Emissions Guidance states that to screen out impacts as 'insignificant' at European and UK statutory designated sites:

- the long-term PC must be less than 1% of the long-term environmental standard (i.e. the Critical Level or Load); and
- the short-term PC must be less than 10% of the short-term environmental standard.

No local nature sites have been identified as requiring assessment.

9.2 Methodology

9.2.1 Atmospheric emissions – Critical Levels

The impact of emissions from the Facility has been compared to the Critical Levels listed in Table 3. For the purpose of the assessment of impacts at ecological sites, the mapped background dataset from APIS has been used. If the PC exceeds the screening criteria detailed in section 9.1, further consideration will be made to the baseline concentrations to determine the PEC and the potential significance of effect.

9.2.2 Deposition of emissions – Critical Loads

In addition to the Critical Levels for the protection of ecosystems, habitat specific Critical Loads for nature conservation sites at risk from acidification and nitrogen deposition (eutrophication) are outlined in APIS.

An assessment has been made for the relevant habitat features identified in APIS for the specific site. The site-specific features tool has been used to identify the feature habitats.

The lowest Critical Loads listed anywhere in each designated site would typically be used to ensure a robust screening assessment. As there is only one European/UK designated site within the relevant screening distances from the Facility, the screening stage has been omitted and the relevant Critical Loads have been determined as follows:

- The most sensitive habitat present within the Teesmouth and Cleveland Coast SSSI/SPA/Ramsar is the coastal sand dune habitat, which is sensitive to nitrogen deposition. The bird species for which the site has been designated are sensitive to the effects of nitrogen deposition but are not sensitive to the effect of acid deposition on the habitats present, with the exception of the great cormorant which is sensitive to the effects of acid deposition on the broad habitat 'standing open water and canals'. However, there is no acidity critical load defined for this habitat type, so it has been excluded from the assessment.
- Saltmarsh habitats within the Teesmouth and Cleveland Coast SSSI/SPA/Ramsar are also sensitive to nitrogen deposition, so the impact on saltmarsh habitats has also been assessed. Saltmarsh is not listed as sensitive to the effects of acid deposition.

The Priority Habitat Inventory (PHI) provided by the UK Government under the Open Government Licence shows that the closest area of saltmarsh lies approximately 3.5 km north of the Facility and the closest area of sand dunes lies approximately 5.5 km northeast of the Facility. Therefore, the maximum impact in areas of saltmarsh and sand dunes has been assessed.

The relevant nitrogen deposition Critical Loads and background levels of deposition are presented in Table 40. No designated features sensitive to acid deposition have been identified.

Table 40: Nitrogen Deposition Critical Loads - Teesmouth and Cleveland Coast SSSI/SPA/Ramsar

Habitat Type	NCL Class	Lower Critical Load (kgN/ha/yr)	Upper Critical Load (kgN/ha/yr)	Background (kgN/ha/yr)(1)
Coastal sand dunes	Coastal stable dune grasslands - acid type	8	10	21.2
Saltmarsh	Pioneer, low-mid, mid-upper saltmarshes	20	30	20.3
Note: (1) *Background deposition taken from the point of maximum impact of the Proposed Facility for each habitat type. Deposition data is not available for the grid square containing sand dunes, so the highest value from an adjacent grid square has been used.*				

The impact has been assessed against these Critical Loads for nitrogen deposition. Where the change in impact or the impact of the Proposed Facility cannot be screened as insignificant, i.e., it is greater than 1% of the Critical Load, further assessment has been undertaken.

9.2.3 Nitrogen deposition calculation methodology

The impact of deposition has been assessed using the methodology detailed within the Habitats Directive AQTAG06[12] (March 2014). The steps to this method are as follows.

1. Determine the annual mean ground level concentrations of nitrogen dioxide and ammonia at each site.
2. Calculate the dry deposition flux (µg/m^2/s) at each site by multiplying the annual mean ground level concentration by the relevant deposition velocity presented in Table 41.
3. Convert the dry deposition flux into units of kgN/ha/yr using the conversion factors presented in Table 41.
4. Compare this result to the nitrogen deposition Critical Load.

Table 41: Deposition Factors

Pollutant	Deposition Velocity (m/s)		Conversion Factor (µg/m^2/s to kg/ha/year)
	Grassland	Woodland	
Nitrogen dioxide	0.0015	0.003	96.0
Ammonia	0.0200	0.030	259.7

9.3 Results - atmospheric emissions - Critical Levels

The impact of emissions from the operation of the Facility has been compared to the Critical Levels, refer to Table 42 and Table 43. The maximum impact at any point in the

12 Air Quality Advisory Group, AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air, March 2014

Teesmouth and Cleveland Coast Ramsar/SPA/SSSI has been presented. The PC has been calculated based on the maximum predicted using all five years of weather data. This assumes operation at the daily ELVs as set out in

Table 16, except ammonia for which operation at the monthly ELV has been assumed. PCs that cannot be screened out in accordance with the screening criteria detailed in section 9.1 have been highlighted.

Table 42: Assessment Against Annual Mean Critical Levels

Site	NOx			SO_2			NH_3		
	Permitted	Proposed	Change	Permitted	Proposed	Change	Permitted	Proposed	Change
Process Contribution as µg/m³									
Teesmouth and Cleveland Coast SPA/Ramsar/SSSI	0.53	0.48	-0.05	0.13	0.12	-0.01	0.026	0.024	-0.003
Process Contribution as % of Critical Level									
Teesmouth and Cleveland Coast SPA/Ramsar/SSSI	**1.76%**	**1.60%**	-0.17%	0.66%	0.60%	-0.06%	0.88%	0.80%	-0.08%

Table 43: Assessment Against Short-Term Critical Levels

Site	Daily Mean NOx			Daily Mean HF			Weekly Mean HF		
	Permitted	Proposed	Change	Permitted	Proposed	Change	Permitted	Proposed	Change
Process Contribution as µg/m³									
Teesmouth and Cleveland Coast SPA/Ramsar/SSSI	6.10	5.44	-0.66	0.030	0.027	0.54%	0.016	0.015	-0.002
Process Contribution as % of Critical Level									
Teesmouth and Cleveland Coast SPA/Ramsar/SSSI	8.13%	7.25%	-0.88%	0.61%	-0.003	-0.07%	3.26%	2.91%	-0.35%

As shown in Table 42 and Table 43, at the only European and UK designated site considered, the Teesmouth and Cleveland Coast SPA/Ramsar/SSSI, the change in PC is less than 1% of the long-term or 10% of the short-term Critical Level and can be screened out as 'insignificant' for all pollutants, and the Proposed Facility PC is less than these screening criteria, except for annual mean NOx. In addition, the impact of the Proposed Facility is lower than the impact of the Permitted Facility. A plot file of the annual mean NOx PC for the Permitted Facility and Proposed Facility is included as Figure 11 of Appendix A.

Consideration has been given to the baseline NOx concentration to determine if there is a risk of exceedance of the Critical Level. The baseline NOx concentration for the point of maximum impact within the Teesmouth and Cleveland Coast SPA/Ramsar/SSSI is 19.94 µg/m³, so the PEC is 20.42 µg/m³ which is 68.1% of the Critical Level. As the EP variation will result in a reduction in PC and the PEC is below 70% of the Critical Level, it is concluded that there is no risk of exceedance of the Critical Level and the impact is 'not significant'.

9.4 Results - deposition of emissions - Critical Loads

The results of the deposition analysis at the Teesmouth and Cleveland Coast SPA/Ramsar/SSSI are presented in Table 44 to Table 46

Table 44: Annual Mean PC used for Deposition Analysis

Site	Habitat	Annual Mean PC (µg/m³)			
		Nitrogen Dioxide		Ammonia	
		Permitted	Permitted	Permitted	Proposed
Teesmouth and Cleveland Coast SSSI/SPA/Ramsar	Saltmarsh	0.19	0.17	0.010	0.009
	Sand dunes	0.12	0.11	0.006	0.005

Table 45: Nitrogen Deposition Calculation at Teesmouth and Cleveland Coast SSSI/SPA/Ramsar

Habitat	Deposition (kg/ha/yr)				N Deposition (kgN/ha/yr)	
	Nitrogen Dioxide		Ammonia			
	Permitted	Proposed	Permitted	Proposed	Permitted	Proposed
Saltmarsh	0.028	0.025	0.050	0.045	0.078	0.069
Sand dunes	0.017	0.015	0.031	0.028	0.048	0.043

Table 46: Nitrogen Deposition at Teesmouth and Cleveland Coast SSSI/SPA/Ramsar

Habitat	Permitted Facility		Proposed Facility		Change	
	PC N dep (kgN/ha/yr)	% of Lower CL	PC N dep (kgN/ha/yr)	% of Lower CL	PC N dep (kgN/ha/yr)	% of Lower CL
Saltmarsh	0.078	0.39%	0.069	0.35%	-0.008	-0.04%
Sand dunes	0.048	0.60%	0.043	0.54%	-0.005	-0.06%

As shown, the process contribution from the Proposed Facility is less than 1% of the lower Critical Loads. Therefore, the impact of the Proposed Facility can be screened out as 'insignificant'.

Furthermore, the change in impact shows a slight reduction in nitrogen deposition at each of the sensitive habitats.

10 Cumulative Sources

Emissions from any significant point source emitters which are already operational will be captured in the baseline pollutant concentrations detailed in section 3. However, emissions from point source emitters which are planned, or have a permit to operate but are not yet operational, will potentially increase baseline pollutant concentrations in the study area. In this instance, it is not considered necessary to include cumulative sources in the baseline concentrations for the following reasons:

1. The Proposed Facility is predicted to have a lower impact than the Permitted Facility for all pollutants except cadmium, mercury, dioxins and group 3 metals, and for pollutants with short-term ELVs;
2. For those pollutants where the PC from the Proposed Facility is higher than the Permitted Facility, only the PC for cadmium exceeds the screening criteria at the point of maximum impact, if it is assumed that cadmium is emitted at the combined cadmium and thallium ELV. Therefore, cadmium is the only pollutant for which consideration of the baseline concentrations could change the conclusions of the assessment.
3. The further analysis presented in section 8.3 shows that the PEC for cadmium at receptor locations is less than 4% of the AQAL. Although some projects in the area which are not yet operational will include emissions of cadmium, there is sufficient headroom that there is no risk that these would increase baseline concentrations to a level where there is a risk of exceedance of the AQAL.

As such, a cumulative impact assessment has not been undertaken.

11 Odour Assessment

The main source of odour from the site will be from the fuel reception and storage building and conveyor system. Odours will be released during the movement and disturbance of the waste derived fuel.

To mitigate odorous air, incoming waste derived fuel will be delivered in enclosed or sheeted vehicles and the waste derived fuel will be unloaded inside the fuel reception building, which is enclosed, with roller shutter doors. The fuel reception building will be held under a slight negative pressure, thereby drawing air into it and reducing the likelihood of air odorous air escaping. All air from within the fuel reception and storage building and conveyor system will be extracted and ducted to the odour carbon filtration system, which forms the odour mitigation system. The carbon filtration system includes a bag filter for the removal of dust and a carbon filter to remove odour. On leaving the carbon filtration system the filtered air will then be released from an odour stack and dispersed into the atmosphere.

Therefore, all fugitive odour sources will be under the control measures above, to reduce any odour release to be from a source point – the odour stack. Emissions from the odour stack will be filtered and are released at height so as to improve dispersion. An air dispersion modelling assessment of the odour impact from the odour stack has been undertaken to confirm that there will not be an unacceptable odour impact.

11.1 Evaluation criteria

There is no specific legislation regarding acceptable or unacceptable odour levels. The primary means of regulation is through the concept of Statutory Nuisance under Part III of the Environmental Protection Act 1990 and under the Permitting Prevention and Control Regulations, where odour is a type of pollution to be regulated. In both cases, the objective of regulation is to ensure that there is no cause for annoyance.

Odours are characterised in terms of European odour units, OU_E. This is defined as the number of times an odour must be diluted, at standard temperature and pressure, to reach the detection limit[13]. The greater amount of dilution required, so the higher the OU_E value, the stronger the odour. Strength however is not the same as offensiveness, as it is possible to have a strong pleasant odour. Therefore, the type of odour must also be considered within assessments.

The Environment Agency have published a guidance note on odour assessment (H4 Odour Management: How to comply with your environmental permit, 2011). This provides benchmark levels for different types of odour, from which to assess whether the odour impact is likely to be unacceptable. These benchmark levels are as below:

- 1.5 OU_E/m^3 for the most offensive odours (e.g. decaying animal or fish remains, septic effluent or sludge, biological landfill)
- 3.0 OU_E/m^3 for moderately offensive odours (e.g. intensive livestock rearing, fat frying or food processing, green waste composting)
- 6.0 OU_E/m^3 for less offensive odours (e.g. brewery, confectionery, coffee)

These values are based on the 98th percentile of hourly averages. This guidance is seconded by the IAQM *Guidance on the assessment of odour for planning,* 2018.

[13] The detection limits are defined as the odour concentration when half of an odour panel can detect the odour. It is often a range of values.

As a conservative measure, the 1.5 OU_E/m^3 odour criteria for most offensive odours has been used as the evaluation criterion for the odour assessment. It is noted that the guidance also states that a local adjustment factor for hypersensitive populations this criterion should be reduced to 1 OUE/m^3. However, due to the industrial surroundings of the Facility, with very few high-sensitivity receptors in the area, it is not considered that the area is hypersensitive to odour.

11.2 Methodology

The detailed flue gas dispersion modelling has been carried out using ADMS 5.2, as for the main dispersion modelling, using five years (2017-2021) of meteorological data from Teesside International Airport . For odour modelling, it is assumed that the odour is caused by a substance which disperses in the atmosphere, in the same way that any other pollutant (such as dust or sulphur dioxide) disperses. The same surface roughness and terrain data as the main dispersion modelling has been used. However, the odour model has used a higher grid resolution of 30 m and a smaller grid of 3.6 km x 3.6 km, which is more appropriate for odour assessment and also includes the residential receptors.

11.2.1 Input data

11.2.1.1 Stack height and buildings

The location of the odour stack, as shown on Figure 8 of Appendix A, is on the existing waste reception hall building, adjacent to where the new reception hall building will be built. A stack height assessment has shown that he minimum height for the odour stack is at 28m. Therefore, this is the height of the odour stack that has been confirmed and the results presented for in this section. A stack height of 28m is 5m taller than the height of the adjacent buildings, and so in line with guidance[14] and practice from the EA that requires that an odour release point to be at least 3 m greater in height than the building it is on or adjacent to.

The odour model has included the existing fuel reception and storage building and the extension building as a singular building, and the boiler hall building. The other buildings are not required for inclusion in the model due to their height lower than one third of the stack height, or their location within the building footprint, considering wind direction from the included buildings. Table 47details the dimensions of the buildings included within the odour model.

Table 47: Building Details for Odour Modelling

Buildings	Centre Point		Height (m)	Length (m)	Width (m)	Angle (°)
	X (m)	Y (m)				
Fuel reception and storage building (including extension)	450951.3	521645.8	22.0	96.5	29.0	0
Boiler Hall (as main dispersion model)	451015.0	521718.0	41.5	41.50	28.0	0

[14] Technical Guidance Notes (Dispersion) D1: Guidelines on Discharge Stack Heights for Polluting Emissions

11.2.1.2 Stack conditions

The odour releases have been characterised as in Table 48. This has been based on an exhaust gas loading from the stack of 1000 OU_E/m^3, which is the odour emission guarantee following treatment by the carbon filtration system.

Table 48: Source Data

Item	Unit	Odour Stack
Stack data		
Height	m	28.0
Internal diameter	m	1.98
Location (E'ings,N'ings)	m, m	450937, 521631
Flue gas exit velocity	m/s	18
Flue Gas Conditions		
Temperature	°C	Ambient
Volume at actual conditions	Am^3/h	200,000
	Am^3/s	55.55
Odour concentration	OU_E/m^3	1,000
Odour release rate	OU_E/s	55,555

11.3 Results

The following table sets out the results for the point of maximum impact. The point of maximum impact for the maximum and 98th percentile of 1 hour means occurs outside of the site boundary

Table 49: Odour Analysis

Odour model results	2017	2018	2019	2020	2021	Max
Maximum of 1-hour odour concentration (OU_E/m^3)	5.50	3.80	3.71	3.46	4.63	**5.50**
98%ile of 1-hour odour concentration (OU_E/m^3)	1.28	1.46	1.43	1.44	1.49	**1.49**

As shown, the highest predicted 98th percentile of hourly means is 1.49 OU_E/m^3, which just is below the odour assessment criterion of 1.5 OU_E/m^3. This is the maximum value under the worst case weather conditions in 5 years. Therefore, it is not considered that the odour impact from the Facility will be unacceptable. Furthermore, the point of maximum impact for the 98th %ile of 1 hour concentrations, although outside the installation boundary, is located in a brownfield area where there is no relevant exposure. The impact at the residential receptors is below under the EA criteria, with the maximum impacted receptor (R3) predicted to experience odour concentrations of 0.15 OU_E/m^3 at the 98th %ile of 1-hour concentrations.

The maximum of 1 hour odour concentrations over the 5 years modelled is 5.50 OU_E/m^3, which may be detectable. However, this maximum is located within the installation boundary. The point maximum 1 hour odour concentrations outside the installation boundary is 3.53 OU_E/m^3. This is predicted to just outside the installation boundary to the east, in an area of brownfield with no expected exposure for members of the public.

As the 98th percentile results are predicted to be much lower than the maximum results, this shows the maximum values are only experienced for a few hours of the year. Furthermore, the odour benchmark recognises this, hence is based on the 98th percentile. At the 98th percentile, the predicted impacts of odour from the Facility are below the benchmark criteria and are therefore considered acceptable.

Figure 12 of Appendix A shows a contour plot of the 98th percentile of hourly averages using the maximum of all 5 years of weather data. As shown, there are no predicted odour concentrations greater than the 1.5 OU_E/m^3 benchmark criteria and the impact at the identified residential receptors is minimal.

It is concluded that there should be no reasonable cause for annoyance due to odour releases from the odour control stack.

12 Conclusions

This Dispersion Modelling Assessment has been undertaken to support an application for a variation to the EP for the Facility. As this is a variation to an existing permitted process a comparison has been made to the impact of the Permitted Facility. To ensure that a direct comparison is being made between the Proposed Facility and Permitted Facility dispersion modelling has been carried out for both. This has been undertaken based on the assumption that for both scenarios the Facility will operate continually at the ELVs.

This assessment has included a review of baseline pollution levels, dispersion modelling of emissions and quantification of the impact of these emissions on local air quality.

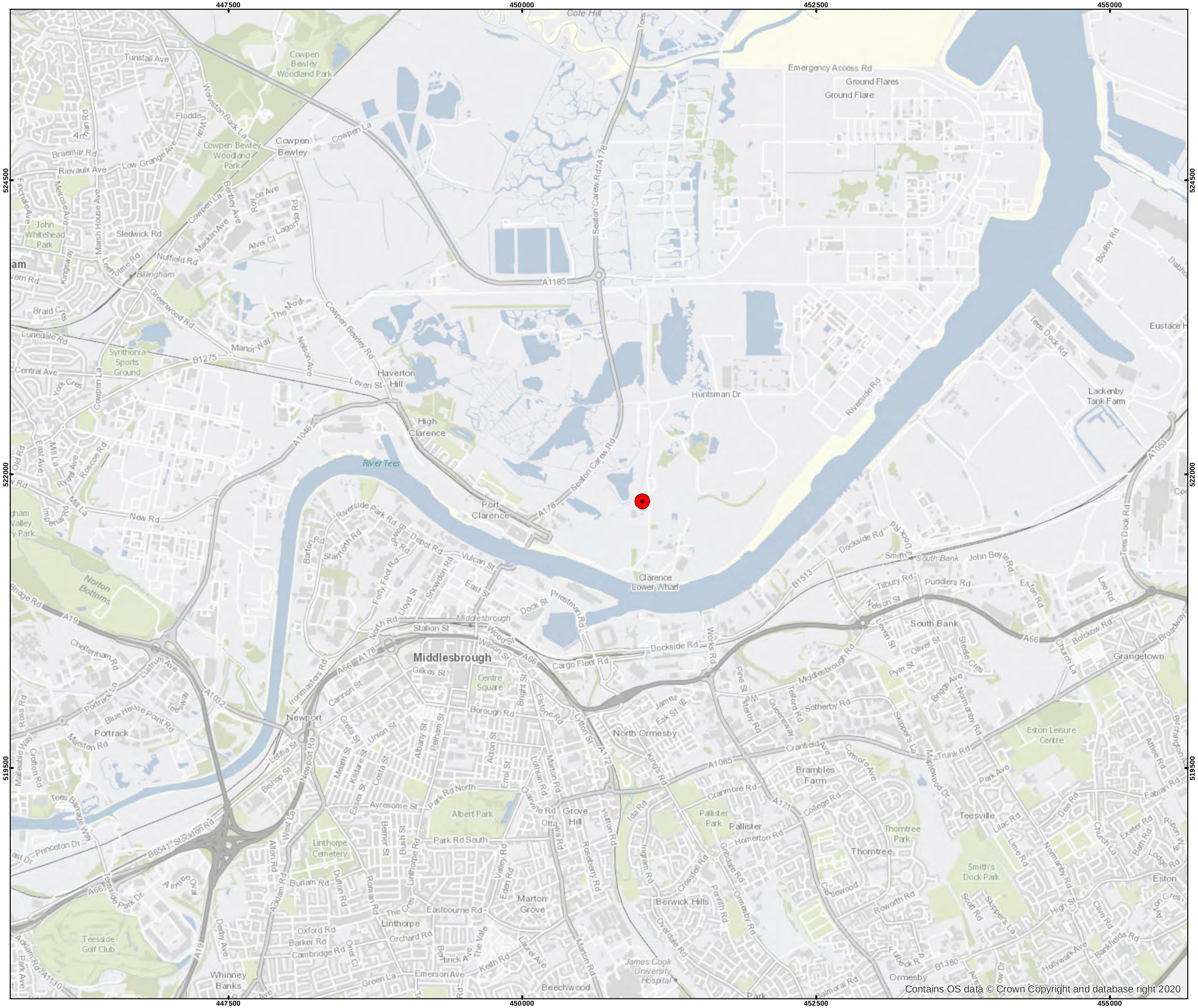
The primary conclusions of the assessment are presented below.

1. In relation to the impact on human health:
    a. Emissions from the operation of the Proposed Facility will not cause a breach of any AQAL.
    b. The PC from the Proposed Facility is lower than the Permitted Facility for all pollutants and averaging periods due to reduced pollutant release rates, except for cadmium, mercury, group 3 metals, dioxins, and pollutants with short-term ELVs.
    c. The change in impact at the point of maximum impact is 'insignificant' for all pollutants and averaging periods.
    d. The PC for the Proposed Facility can be screened out as 'insignificant' for all pollutants and averaging periods except for annual mean VOCs as 1,3-butadiene. For those pollutants which cannot be screened out as 'insignificant', further analysis has been undertaken which shows that there is no risk of exceedance of an AQAL, and no significant impacts are predicted.
2. In relation to the impact on ecologically sensitive sites:
    a. The impact of the Proposed Facility, and the change in impact, can be screened out as 'insignificant' at the identified ecological receptor (the Teesmouth and Cleveland Coast SSSI/SPA/Ramsar), with the exception of the impact of the Proposed Facility on annual mean oxides of nitrogen.
    b. When the baseline concentration of oxides of nitrogen is taken into account, the PEC is less than 70% of the Critical Level so the impact is 'not significant'.
3. In relation to the impact of odour emissions:
    a. The maximum odour concentration is predicted to be less than the benchmark of 1.5 OU_E/m^3 for 'highly offensive' odours. The odour concentrations at high sensitivity receptors is predicted to be much lower. Therefore, that there should be no reasonable cause for annoyance due to odour releases from the odour control stack.

In summary, the assessment has shown that the change in impact as a result of varying the EP to change the Facility from a waste co-incineration plant to an incineration plant would not have a significant impact on local air quality, the general population or the local community.

Appendices

A Figures



Legend

● Stack

Note:

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	Figure 1: Site Location

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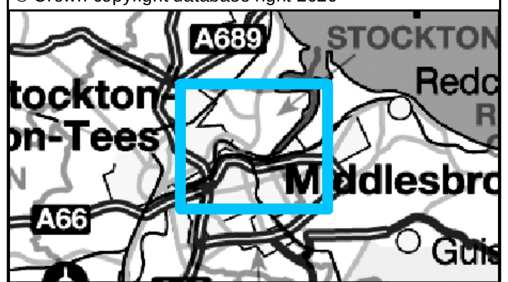

0 0.3 0.6 1.2 km

N

Scale: 1:30,000

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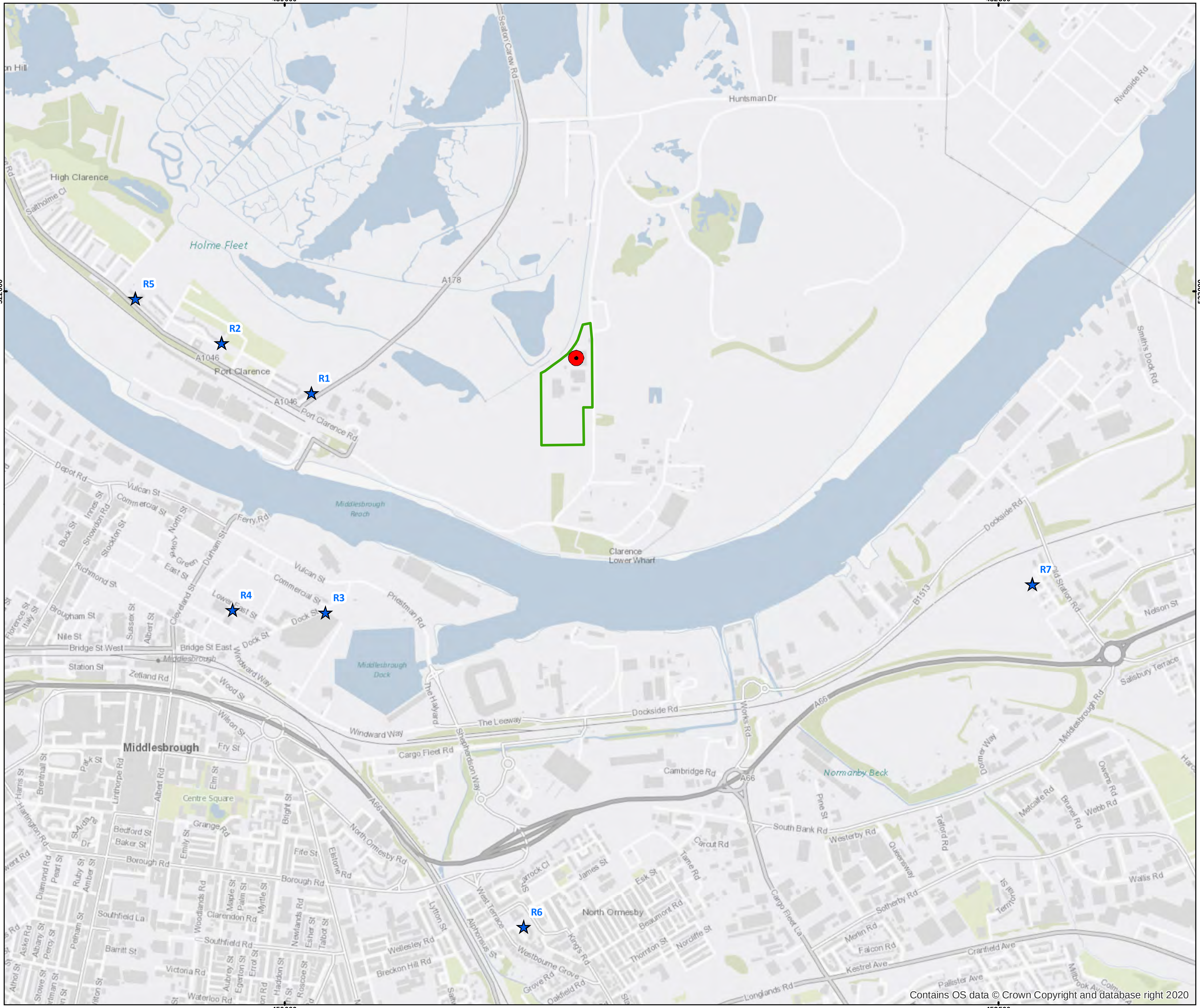

Legend

- ★ Human Receptors
- ● Stack
- ▭ Installation Boundary

Note:

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	Figure 2: Human Sensitive Receptors

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0 0.125 0.25 0.5 km

N

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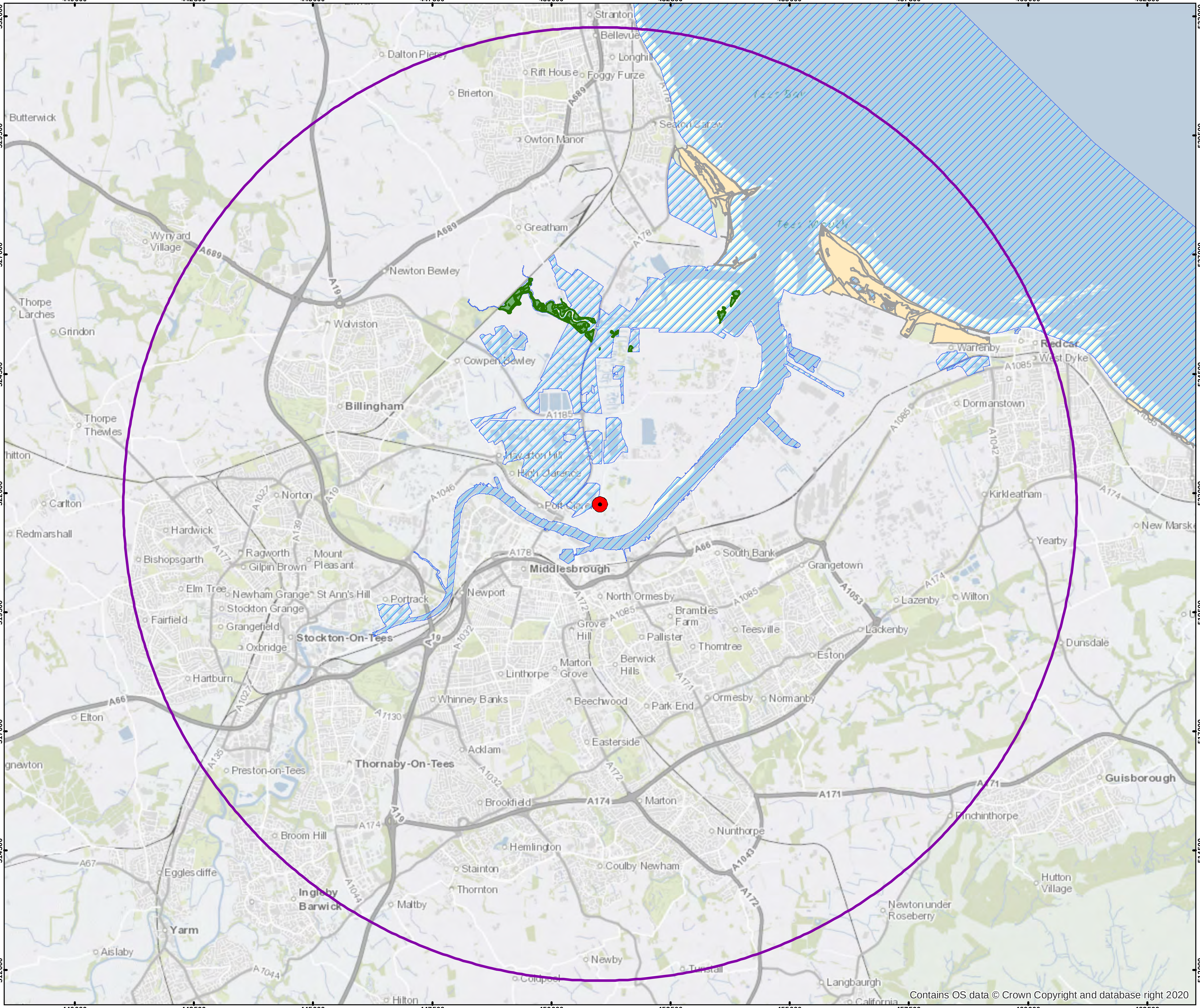

Legend

- Stack
- 10 km Buffer
- Sand Dune Habitats
- Saltmarsh Habitats
- Teesmouth and Cleveland Coast

Note:

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	

Figure 3: Ecological Sensitive Receptors

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0 0.75 1.5 3 km

Scale: 1:75,000

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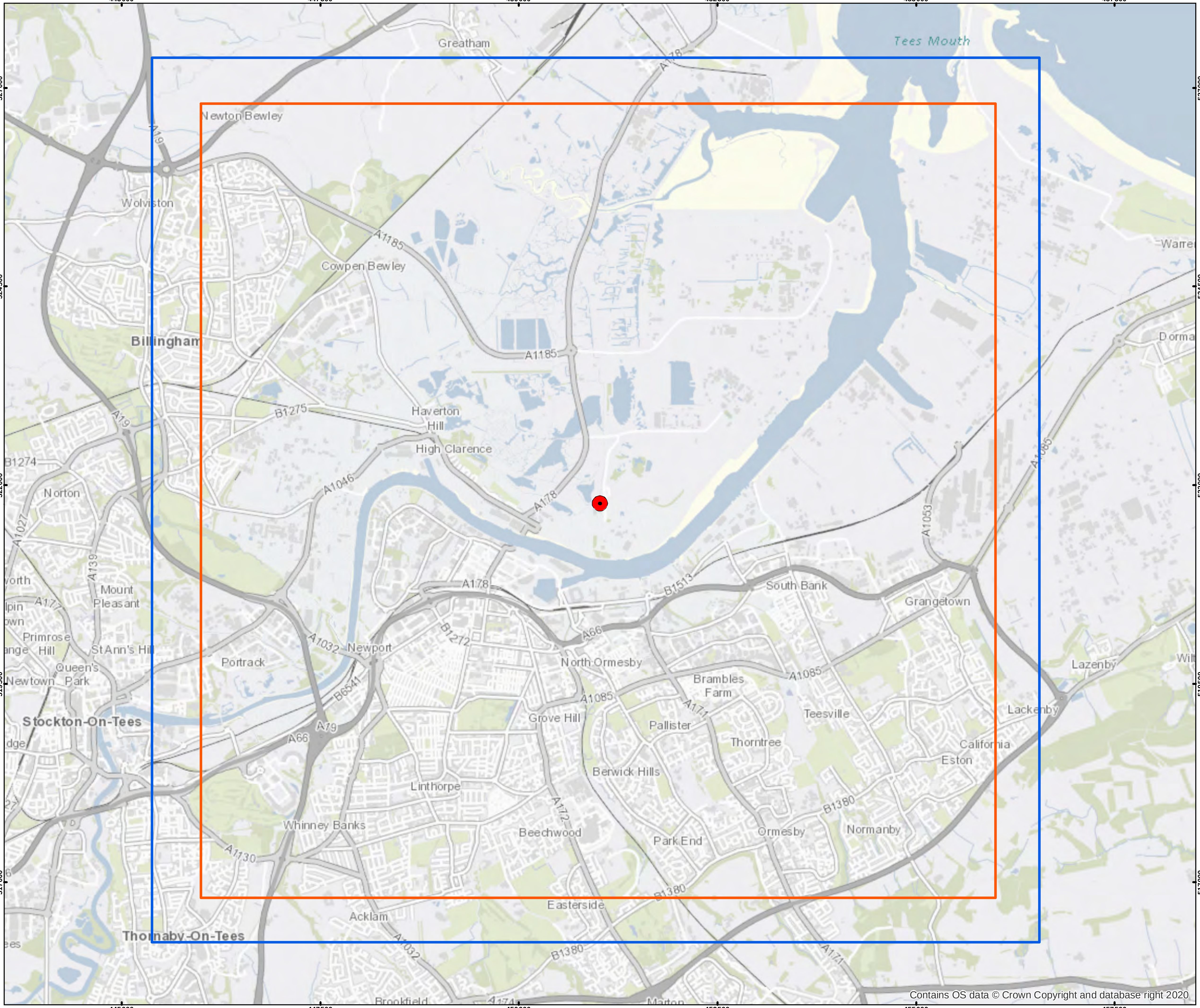

Legend

- Stack
- Output Grid Extent
- Terrain and Surface Roughness File Extent

Note:

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	

Figure 4: Model Inputs

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0 0.475 0.95 1.9 km

Scale: 1:45,000

N

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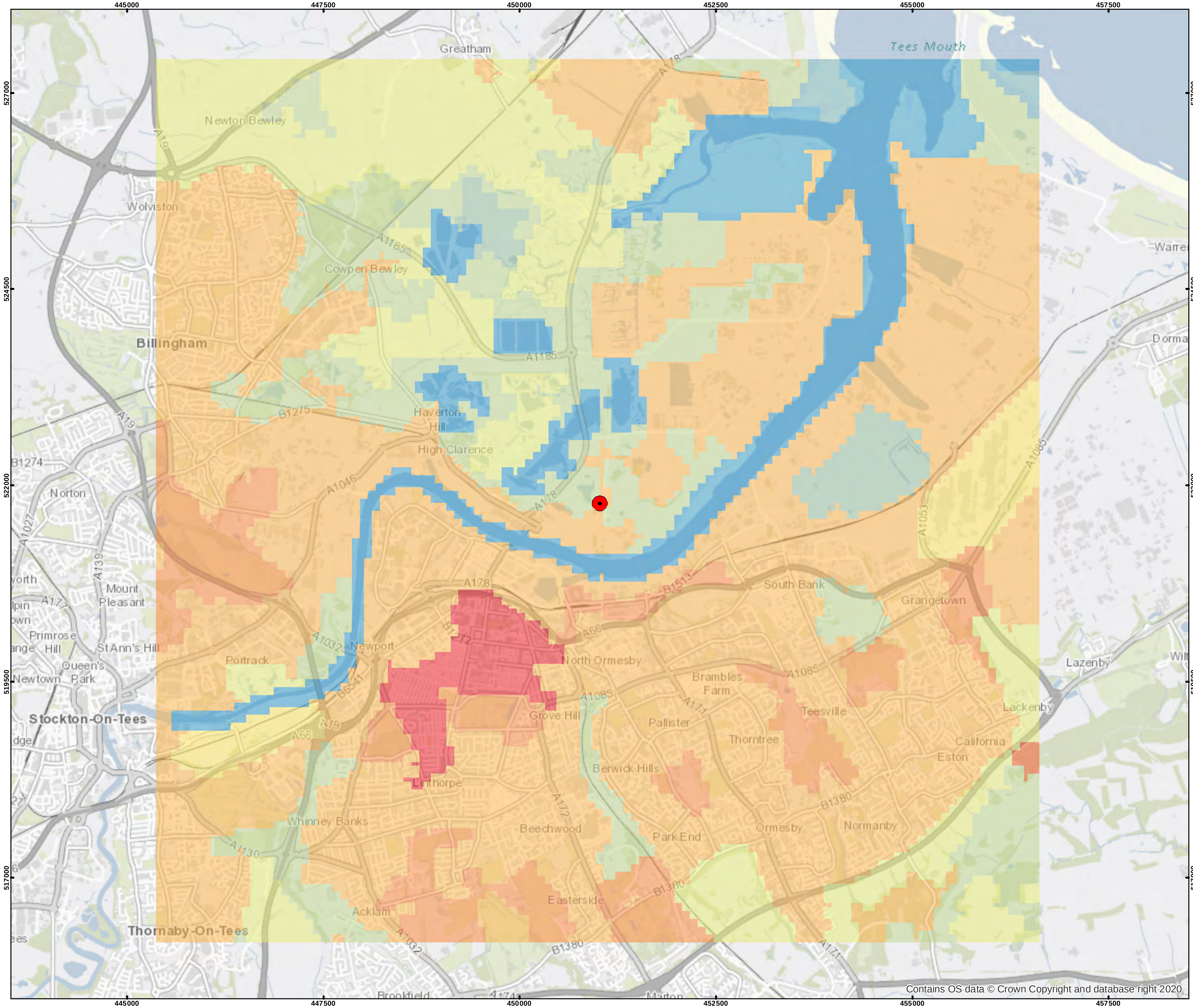

Legend

Stack

Surface roughness length (m)

- 0.0001
- 0.0005
- 0.005
- 0.03
- 0.05
- 0.075
- 0.5
- 0.6
- 0.75
- 1.2

Note:

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	

Figure 5: Surface Roughness File

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0 0.475 0.95 1.9 km

Scale: 1:45,000

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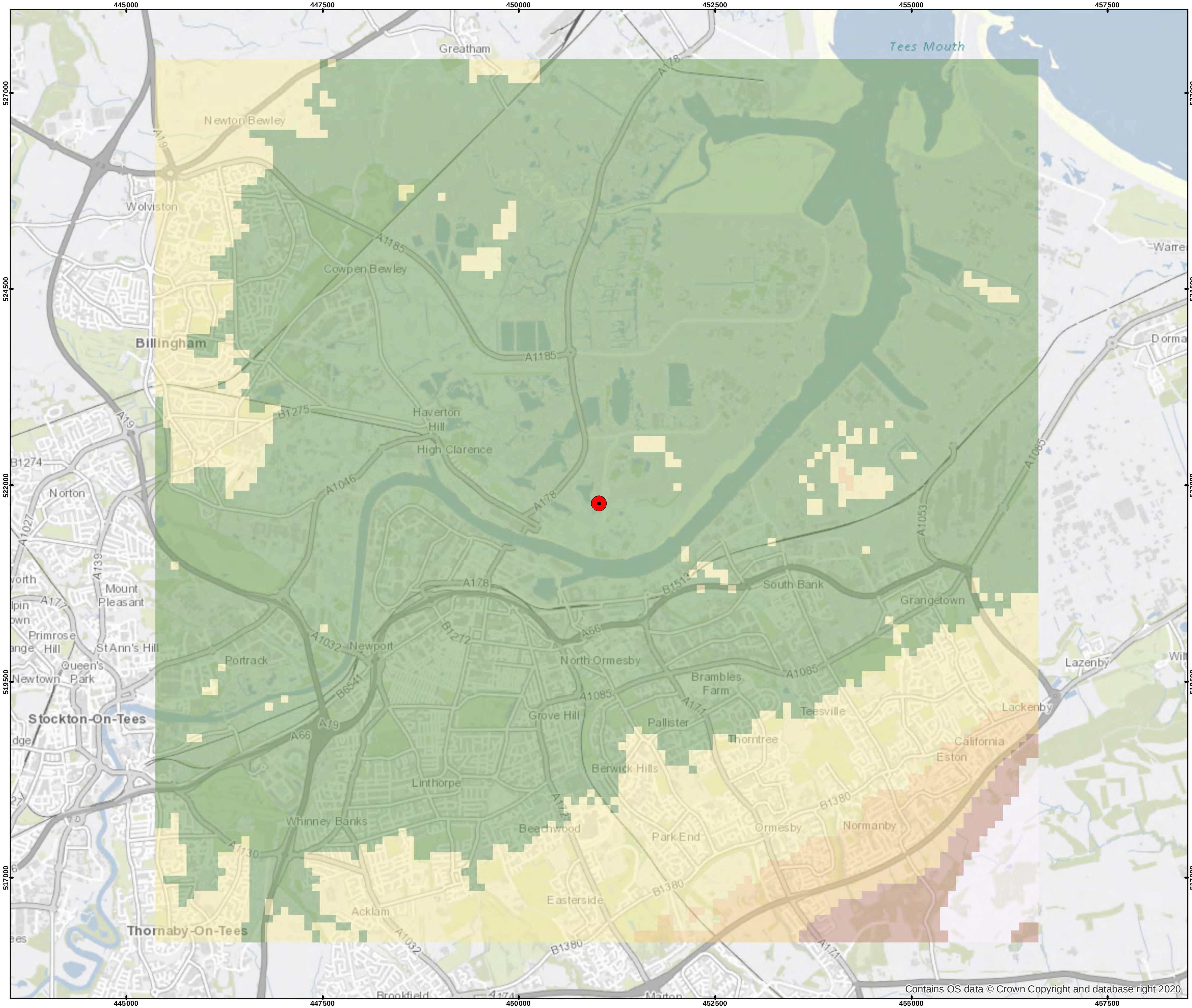

Legend

Stack

Elevation (m)

- <15
- 15 - 40
- 40 - 80
- 80 - 150
- >150

Note:

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	

Figure 6: Terrain File

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0 0.475 0.95 1.9 km

Scale: 1:45,000

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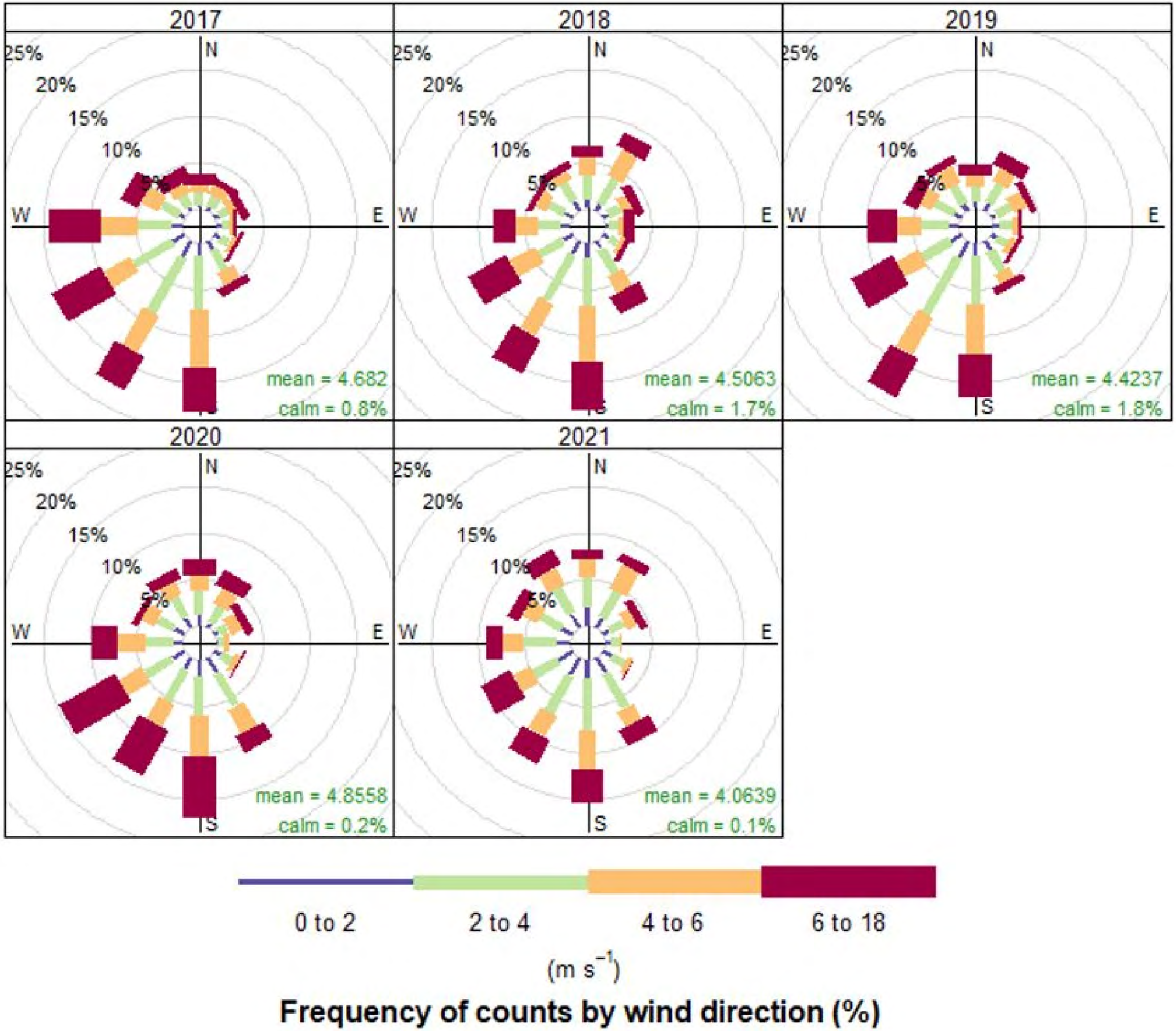

Client:	Port Clarence Energy Limited
Site:	Teeside Renewable Energy Plant
Project:	3740
Title:	

Figure 7: Wind Roses Teesside International Airport 2017-2021

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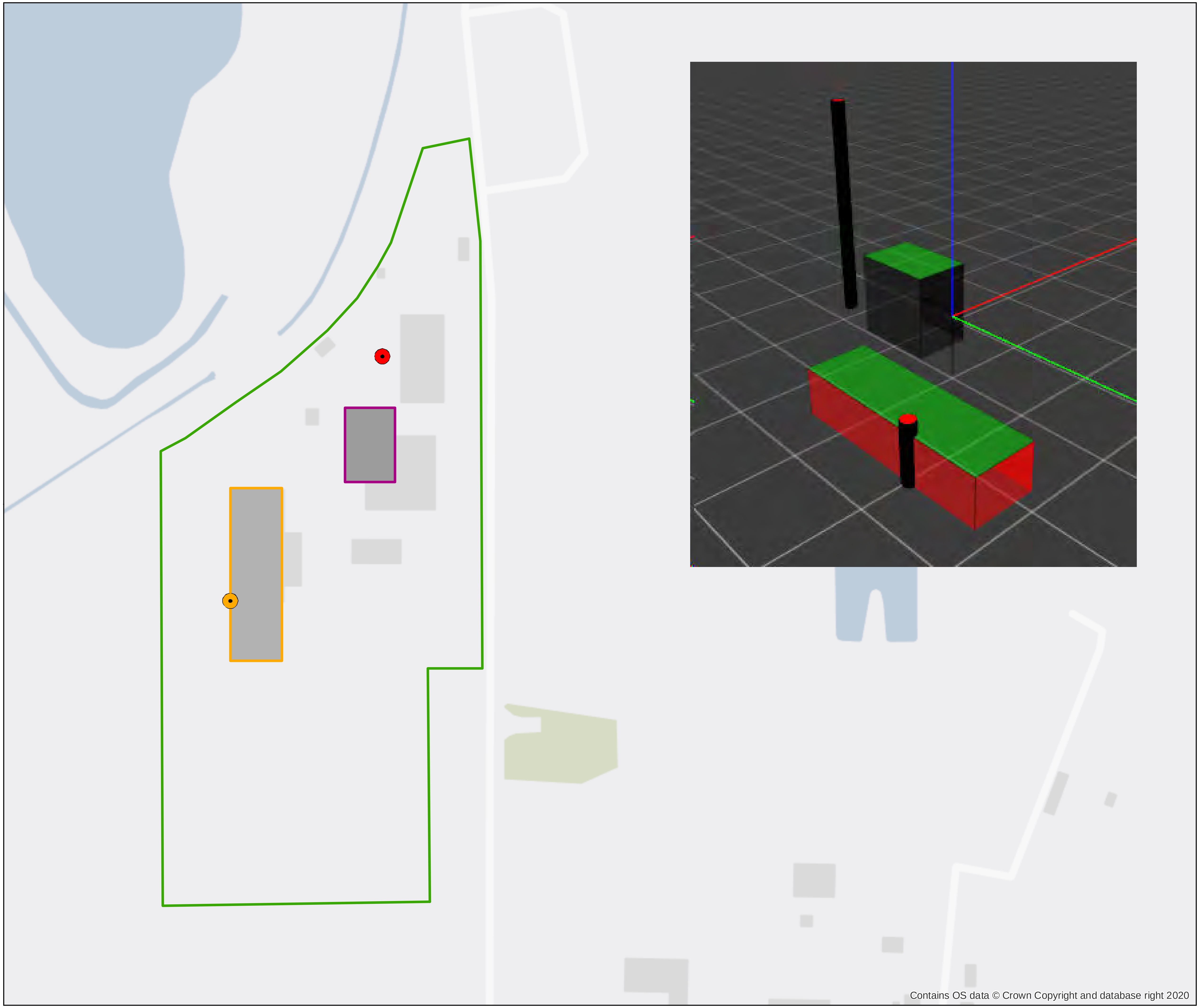

Legend

- Installation Boundary
- Main Stack
- Odour Stack
- Boiler Hall
- Fuel Reception and Storage Building

Note:

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	

Figure 8: Buildings Modelled

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0 0.02 0.04 0.08 km

N

Scale: 1:2,000

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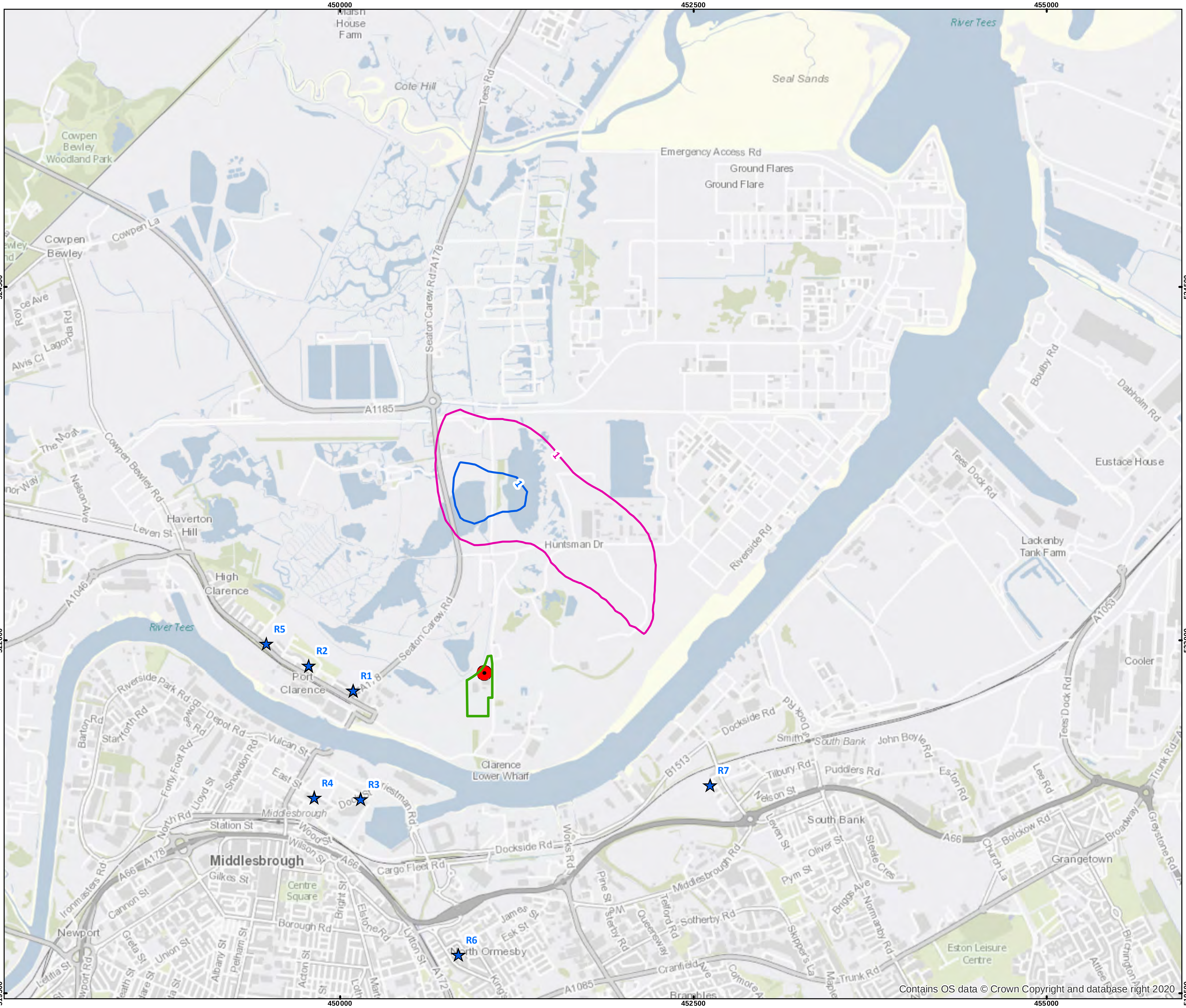

Legend

- Installation Boundary
- Main Stack
- Human Receptors
- Annual mean 1,3-butadiene as % of AQAL - Proposed Facility
- Annual mean 1,3-butadiene as % of AQAL - Permitted Facility

Note:
Assumes all VOCs emitted as 1,3-Butadiene

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	Figure 9: Annual Mean 1,3-Butadiene

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0 0.25 0.5 1 km

N

Scale: 1:25,000

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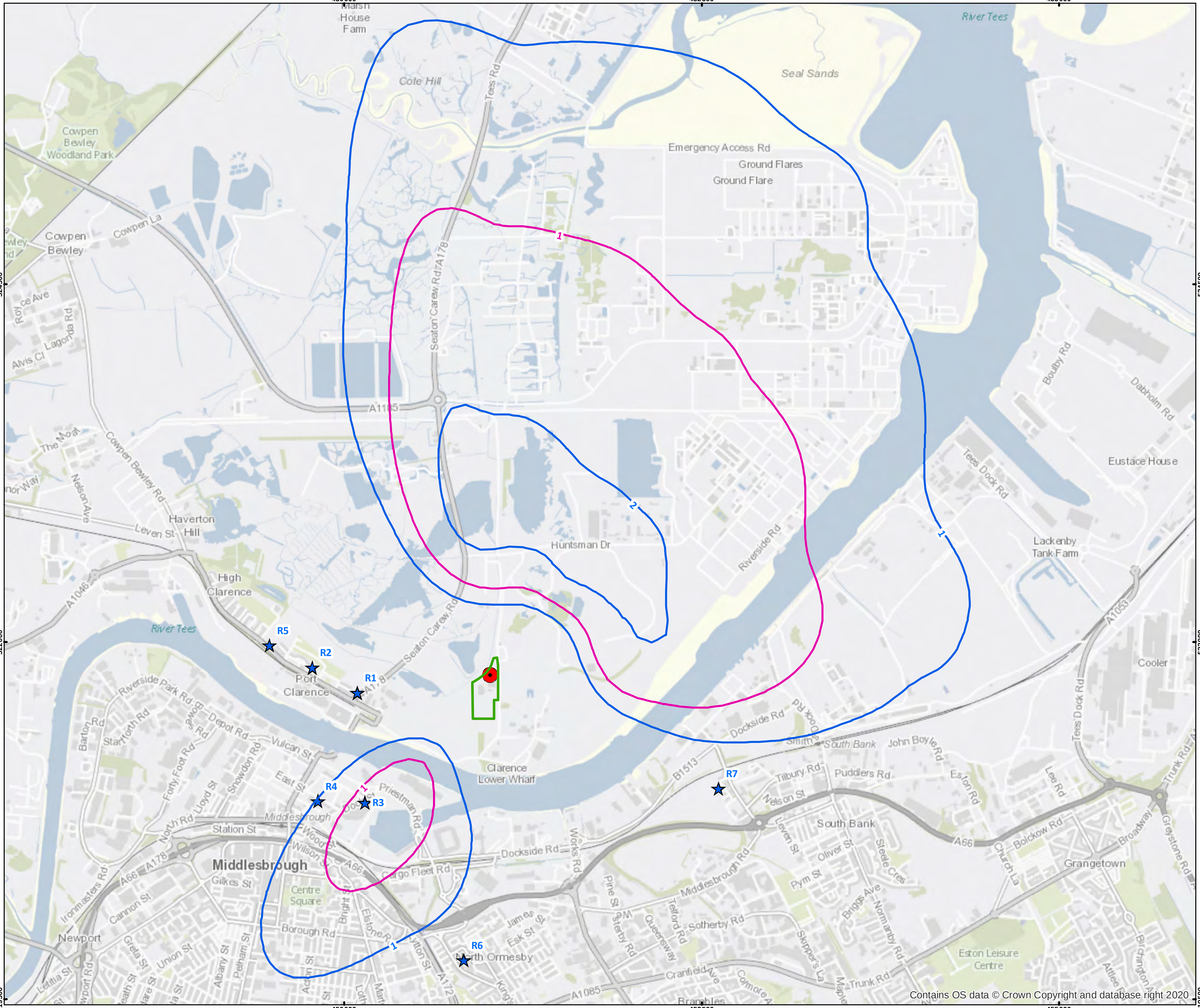

Legend

- Installation Boundary
- Main Stack
- Human Receptors
- Annual mean cadmium (screening) as % of AQAL - Proposed Facility
- Annual mean cadmium (screening) as % of AQAL - Permitted Facility

Note:
Assumes cadmium emitted at combined cadmium and thallium emission limit

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	Figure 10: Annual Mean Cadmium

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0 0.25 0.5 1 km

Scale: 1:25,000

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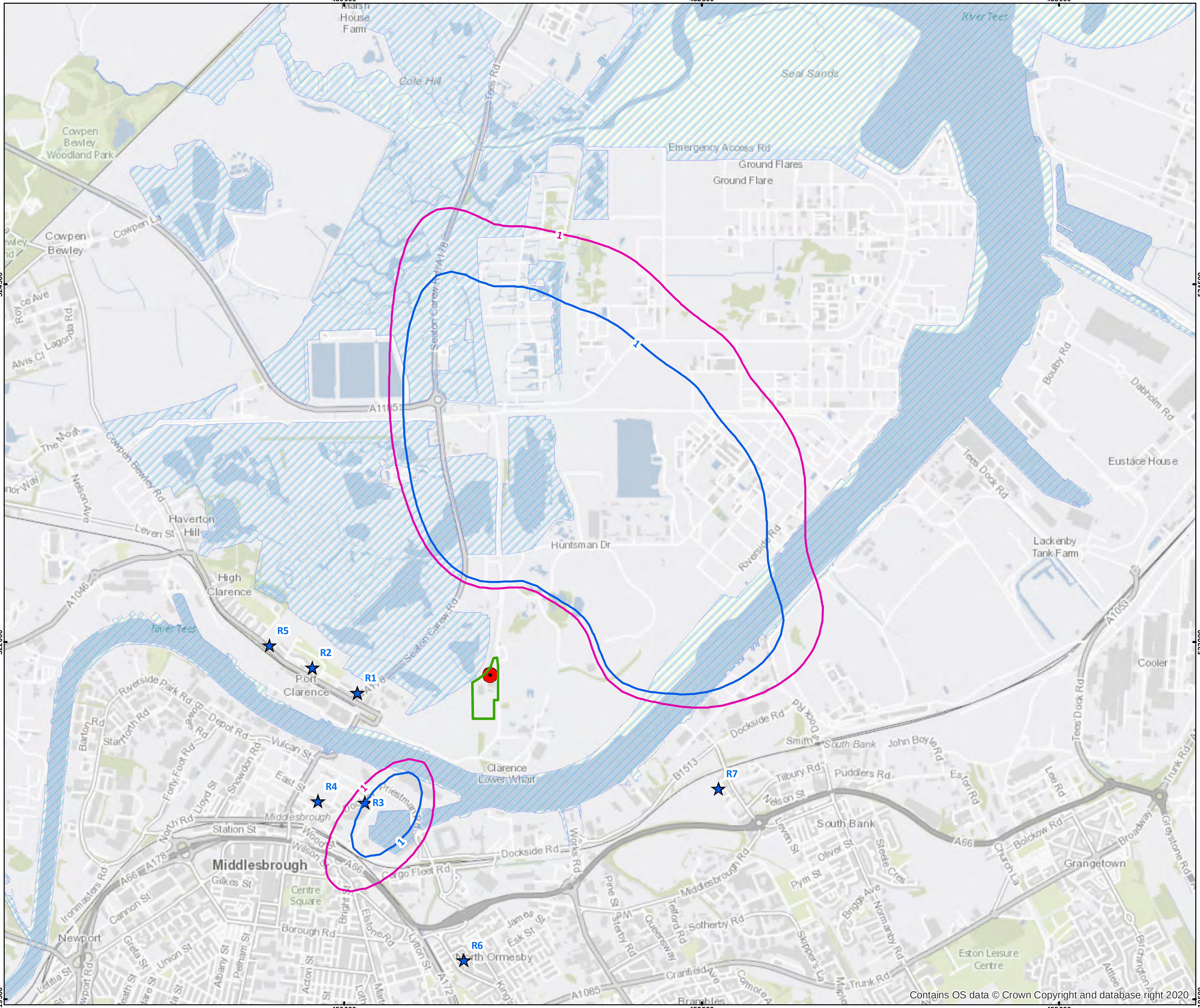

Legend

- Installation Boundary
- Main Stack
- Human Receptors
- Teesmouth and Cleveland Coast
- Annual mean NOx as % of Critical Level - Permitted Facility
- Annual mean NOx as % of Critical Level - Permitted Facility

Client:	Port Clarence Energy Ltd
Site:	Teesside Renewable Energy Plant
Project:	3740-06 EP Application
Title:	Figure 11: Annual Mean NOx

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0 0.25 0.5 1 km

N

Scale: 1:25,000

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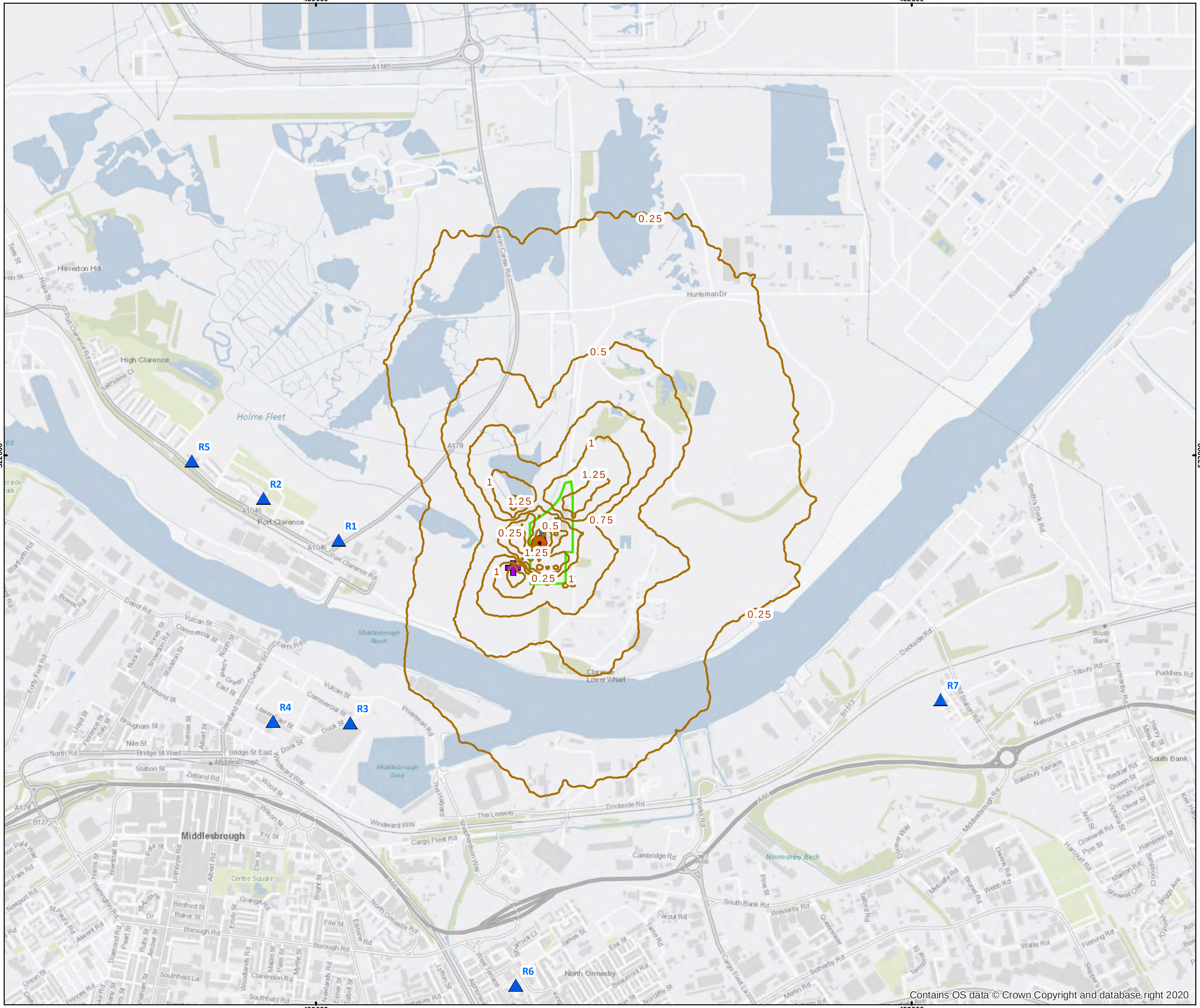

Legend

- Permit boundary
- Odour Stack
- Modelled buildings
- Receptors
- Point of maximum impact
- 98th %ile of 1 hour odour (OUe/m3)

Client:	Port Clarence Energy Limited
Site:	Teesside Renewable Energy Plant
Project:	3740
Title:	Figure 12: Odour impact, 98th percentile of 1 hour means
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0 0.15 0.3 0.6 km

Scale: 1:15,000

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B Detailed Results Tables

Table 50: Dispersion Modelling Results – PC at Point of Maximum Impact - Daily ELVs – Permitted Facility

Pollutant	Quantity	Units	AQAL	Bg Conc.	2017	2018	2019	2020	2021	Max	Max as % of AQAL	PEC	PEC as % of AQAL
Nitrogen dioxide	Annual mean	µg/m³	40	28.68	0.35	0.37	0.34	0.36	0.34	0.37	0.93%	29.05	72.63%
	99.79th %ile of hourly means	µg/m³	200	57.36	5.54	5.88	5.64	5.28	6.39	6.39	3.19%	63.75	31.87%
Sulphur dioxide	99.18th %ile of daily means	µg/m³	125	4.00	0.94	1.13	1.10	0.90	1.07	1.13	0.90%	5.13	4.10%
	99.73rd %ile of hourly means	µg/m³	350	4.00	3.59	3.98	3.88	3.53	4.30	4.30	1.23%	8.30	2.37%
	99.9th %ile of 15 min. means	µg/m³	266	4.00	5.04	5.59	5.34	4.89	5.63	5.63	2.12%	9.63	3.62%
Particulates (PM_{10})	Annual mean	µg/m³	40	18.00	0.03	0.03	0.02	0.03	0.02	0.03	0.07%	18.03	45.07%
	90.4th %ile of daily means	µg/m³	50	36.00	0.09	0.10	0.09	0.09	0.09	0.10	0.20%	36.10	72.20%
Particulates ($PM_{2.5}$)	Annual mean	µg/m³	20	10.00	0.03	0.03	0.02	0.03	0.02	0.03	0.13%	10.03	50.13%
Carbon monoxide	8 hour running mean	µg/m³	10,000	764	3.91	4.58	5.57	5.75	3.24	5.75	0.06%	769.75	7.70%
	Hourly mean	µg/m³	30,000	764	8.81	9.57	8.91	8.22	9.09	9.57	0.03%	773.57	2.58%
Hydrogen chloride	Hourly mean	µg/m³	750	1.42	1.76	1.91	1.78	1.64	1.82	1.91	0.26%	3.33	0.44%
Hydrogen fluoride	Annual mean	µg/m³	16	2.35	0.003	0.003	0.002	0.003	0.002	0.003	0.02%	2.35	14.70%
	Hourly mean	µg/m³	160	4.70	0.18	0.19	0.18	0.16	0.18	0.19	0.12%	4.89	3.06%
Ammonia	Annual mean	µg/m³	180	3.40	0.02	0.02	0.02	0.02	0.02	0.02	0.01%	3.42	1.90%
	Hourly mean	µg/m³	2,500	6.80	1.76	1.91	1.78	1.64	1.82	1.91	0.08%	8.71	0.35%

Pollutant	Quantity	Units	AQAL	Bg Conc.	2017	2018	2019	2020	2021	Max	Max as % of AQAL	PEC	PEC as % of AQAL
VOCs (as benzene)	Annual mean	µg/m³	5	1.10	0.03	0.03	0.02	0.03	0.02	0.03	0.53%	1.13	22.53%
	Daily mean	µg/m³	30	2.20	0.24	0.31	0.27	0.29	0.26	0.31	1.02%	2.51	8.36%
VOCs (as 1,3-butadiene)	Annual mean	µg/m³	2.25	0.32	0.03	0.03	0.02	0.03	0.02	0.03	1.18%	0.35	15.40%
Mercury	Annual mean	ng/m³	250	2.10	0.08	0.09	0.08	0.08	0.08	0.09	0.04%	2.19	0.88%
	Hourly mean	ng/m³	7,500	4.20	5.88	6.38	5.94	5.48	6.06	6.38	0.09%	10.58	0.14%
Cadmium	Annual mean	ng/m³	5	0.12	0.08	0.09	0.08	0.08	0.08	0.09	1.76%	0.21	4.16%
PaHs	Annual mean	pg/m³	250	180	0.50	0.53	0.49	0.51	0.49	0.53	0.21%	180.53	72.21%
Dioxins and Furans	Annual mean	fg/m³	-	32.99	0.17	0.18	0.16	0.17	0.16	0.18	-	33.17	-
PCBs	Annual mean	ng/m³	200	0.13	0.01	0.01	0.01	0.01	0.01	0.01	0.01%	0.14	0.07%
	Hourly mean	ng/m³	6,000	0.26	0.88	0.96	0.89	0.82	0.91	0.96	0.02%	1.22	0.02%

Note:
Assumes continuous operation at the daily ELVs.

Table 51: Dispersion Modelling Results – PC at Point of Maximum Impact - Daily ELVs – Proposed Facility

Pollutant	Quantity	Units	AQAL	Bg Conc.	2017	2018	2019	2020	2021	Max	Max as % of AQAL	PEC	PEC as % of AQAL
Nitrogen dioxide	Annual mean	µg/m³	28.68	0.32	0.34	0.31	0.32	0.31	0.34	0.84%	29.02	72.54%	28.68
	99.79th %ile of hourly means	µg/m³	57.36	4.96	5.28	5.08	4.77	5.78	5.78	2.89%	63.14	31.57%	57.36
Sulphur dioxide	99.18th %ile of daily means	µg/m³	4.00	0.84	1.01	0.99	0.80	0.96	1.01	0.81%	5.01	4.01%	4.00
	99.73rd %ile of hourly means	µg/m³	4.00	3.22	3.59	3.50	3.15	3.88	3.88	1.11%	7.88	2.25%	4.00
	99.9th %ile of 15 min. means	µg/m³	4.00	4.50	5.01	4.81	4.26	4.94	5.01	1.88%	9.01	3.39%	4.00
Particulates (PM_{10})	Annual mean	µg/m³	18.00	0.02	0.02	0.02	0.02	0.02	0.02	0.06%	18.02	45.06%	18.00
	90.4th %ile of daily means	µg/m³	36.00	0.08	0.09	0.08	0.08	0.08	0.09	0.18%	36.09	72.18%	36.00
Particulates ($PM_{2.5}$)	Annual mean	µg/m³	10.00	0.02	0.02	0.02	0.02	0.02	0.02	0.12%	10.02	50.12%	10.00
Carbon monoxide	8 hour running mean	µg/m³	764	3.52	4.09	4.97	5.14	2.92	5.14	0.05%	769.14	7.69%	764
	Hourly mean	µg/m³	764	8.00	8.68	8.16	7.11	8.28	8.68	0.03%	772.68	2.58%	764
Hydrogen chloride	Hourly mean	µg/m³	1.42	1.60	1.74	1.63	1.42	1.66	1.74	0.23%	3.16	0.42%	1.42
Hydrogen fluoride	Annual mean	µg/m³	2.35	0.002	0.002	0.002	0.002	0.002	0.002	0.01%	2.35	14.70%	2.35
	Hourly mean	µg/m³	4.70	0.16	0.17	0.16	0.14	0.17	0.17	0.11%	4.87	3.05%	4.70
Ammonia	Annual mean	µg/m³	3.40	0.02	0.02	0.02	0.02	0.02	0.02	0.01%	3.42	1.90%	3.40
	Hourly mean	µg/m³	6.80	1.60	1.74	1.63	1.42	1.66	1.74	0.07%	8.54	0.34%	6.80
	Annual mean	µg/m³	1.10	0.02	0.02	0.02	0.02	0.02	0.02	0.48%	1.12	22.48%	1.10

Pollutant	Quantity	Units	AQAL	Bg Conc.	2017	2018	2019	2020	2021	Max	Max as % of AQAL	PEC	PEC as % of AQAL
VOCs (as benzene)	Daily mean	µg/m³	2.20	0.21	0.27	0.25	0.26	0.23	0.27	0.92%	2.47	8.25%	2.20
VOCs (as 1,3-butadiene)	Annual mean	µg/m³	0.32	0.02	0.02	0.02	0.02	0.02	0.02	1.06%	0.34	15.29%	0.32
Mercury	Annual mean	ng/m³	2.10	0.11	0.12	0.11	0.12	0.11	0.12	0.05%	2.22	0.89%	2.10
	Hourly mean	ng/m³	4.20	8.00	8.68	8.16	7.11	8.28	8.68	0.12%	12.88	0.17%	4.20
Cadmium	Annual mean	ng/m³	0.12	0.11	0.12	0.11	0.12	0.11	0.12	2.39%	0.24	4.79%	0.12
PaHs	Annual mean	pg/m³	180	0.45	0.48	0.44	0.46	0.44	0.48	0.19%	180.48	72.19%	180
Dioxins and Furans	Annual mean	fg/m³	32.99	0.23	0.24	0.22	0.23	0.22	0.24	-	33.23	-	32.99
PCBs	Annual mean	ng/m³	0.13	0.01	0.01	0.01	0.01	0.01	0.01	0.01%	0.14	0.07%	0.13
	Hourly mean	ng/m³	0.26	0.80	0.87	0.82	0.71	0.83	0.87	0.01%	1.13	0.02%	0.26

Note:
Assumes continuous operation at the daily ELVs.

Table 52: Dispersion Modelling Results – PC at Point of Maximum Impact - Short-Term ELVs – Proposed Facility

Pollutant	Quantity	Units	AQAL	Background Conc.	2016	2017	2018	2019	2020	Max	Max as % of AQAL	PEC	PEC as % of AQAL
Nitrogen dioxide	99.79th %ile of hourly means	µg/m³	200	57.36	9.92	10.56	10.15	9.53	11.55	11.55	5.78%	68.91	34.46%
Sulphur dioxide	99.73rd %ile of hourly means	µg/m³	350	4.00	12.88	14.35	13.99	12.59	15.53	15.53	4.44%	19.53	5.58%
	99.9th %ile of 15 min. means	µg/m³	266	4.00	18.01	20.05	19.26	17.02	19.76	20.05	7.54%	24.05	9.04%
Carbon monoxide	8 hour running mean	µg/m³	10,000	764	10.55	12.26	14.92	15.43	8.75	15.43	0.15%	779.43	7.79%
	Hourly mean	µg/m³	30,000	764	23.99	26.05	24.48	21.33	24.84	26.05	0.09%	790.05	2.63%
Hydrogen chloride	Hourly mean	µg/m³	750	1.42	9.59	10.42	9.79	8.53	9.93	10.42	1.39%	11.84	1.58%
Hydrogen fluoride	Hourly mean	µg/m³	160	4.70	0.64	0.69	0.65	0.57	0.66	0.69	0.43%	5.39	3.37%

Note:
Assumes continuous operation at the short term ELVs

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